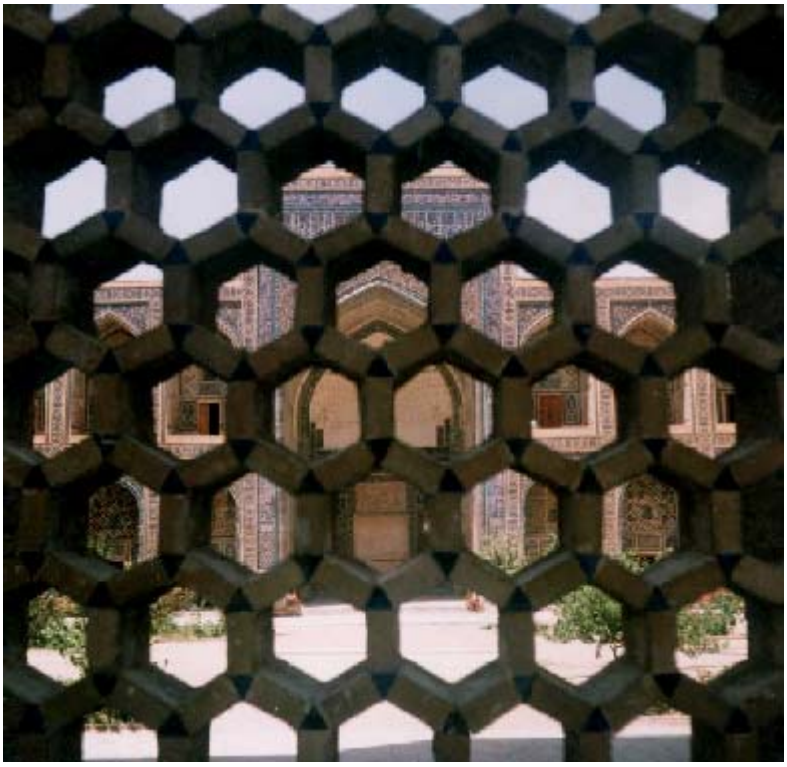
QUANTUM COMPLEXITIES IN CONDENSED MATTER

August 21-28, 2003
Bukhara, Uzbekistan



PROGRAM AND ABSTRACTS

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QUANTUM COMPLEXITIES IN CONDENSED MATTER

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Special thanks to Raisa Gareyeva and her team at Salom Travel for assistance with local arrangements and travel and to Geri, Irina and Eugene for secretarial assistance.

INVITED SPEAKERS

M. Abd-Elmeguid (Cologne).
I. Atabaev (Tashkent).
G. Baskaran (Madras).
B. Batlogg (Zurich).
C. Bergemann (Cambridge).
N.B. Beisenkhanov (Almaty).
G. Chapline (Lawrence Livermore Labs).
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S. Suleimanov (Tashkent).
J. Takeya (Tokyo).
N.A. Taylanov (Tashkent).
V. Tripathi (Cambridge).
P. van Loosdrecht (Groningen).
U.V. Valiev
A.N. Vasilev (Moscow).
S. Wells (London).
A.V. Zenkov (Ekaterinburg).

PROGRAM

Scientific Sessions are in the Bukhara Palace Hotel

Thursday, August 21:

19:00 Registration
20:00 Welcome Reception

Friday, August 22:

09:00-10:00 Opening Ceremony

10:00-10:30 Tea/Coffee

Oral Session (Chair, Saxena):
10:30-11:00 Singh
11:00-11:30 Lonzarich
11:30-12:00 Chapline
12:00-12:30 Miyake

Lunch
16:00-16:30 Tea/Coffee

Oral Session (Chair, Miyake):
16:30-17:00 Gehring
17:00-17:30 Abd-Elmeguid
17:30-17:50 Steiner
17:50-18:10 Suleimanov
18:10-18:30 Atabaev

19:30 Dinner

Saturday, August 23

Oral Session (Chair, Khomskii):
09:00-10:00 Bergemann (Tutorial): Experimental Investigations of Electronic Structure in Correlated Materials

10:00-10:30 Tea/Coffee

Oral Session (Chair, Lonzarich):

10:30-11:00	Baskaran
11:00-11:20	Ozcan
11:20-11:40	Dzhumanov
11:40-12:00	Kumagai
12:00-12:20	Taylanov
12:20-12:40	Ibragimova

Lunch

16:00-16:30 Tea/Coffee

Oral Session (Chair, Spalek):

16:30-17:30 Tripathi (Tutorial): Theoretical Concepts 1.

17:30-19:30 Poster Session I

18:30 Departure for sight-seeing tour of Samrakand
(those interested in this trip please contact Montu Saxena at: sss21@phy.cam.ac.uk)

19:30 Dinner

Sunday, August 24

Oral Session (Chair, Spalek)

0900-10:00 Tripathi (Tutorial): Theoretical Concepts 2.

10:00-10:30 Tea/Coffee

10:30-12:00 Discussion Session

Lunch

Day trip

Monday, August 25

Oral Session (Chair, Wells):

09:00-10:00 Singh (tutorial):
First Principles Investigation of Materials Properties

10:00-10:30 Tea/Coffee

Oral Session (Chair, Singh):

10:30-11:00	Ibragimova
11:00-11:30	Wells
11:30-11:50	Mukimov
11:50-11:10	Valiev
12:10-12:30	Beisenkhanov

Lunch

16:00-16:30	Tea/Coffee

Oral Session (Chair, Kusmartsev):

16:30-17:00	Khomskii
17:00-17:20	Zenkov
17:20-17:50	Kugel
17:50-18:10	Efremov

19:30 Dinner

Tuesday, August 26

Oral Session (Chair, Mukimov):

09:00-10:00	Fiebig (Tutorial): Nonlinear Optics for the Investigation of Magnetic Structures

10:00-10:30	Tea/Coffee

Oral Session (Chair, Bergemann):

10:30-11:00	Inoue
11:00-11:30	Palstra
11:30-11:50	Michenko
11:50-12:10	Salkhitdinova
12:10-12:40	Kusmartsev
12:40-13:00	Zenkov

Lunch

16:00-16:30	Tea/Coffee

Oral Session (Chairs, Chiao & Vasilev):

16:30-17:00	Vasilev
17:00-17:30	Batlogg
17:30-18:00	Takeya
18:00-18:30	van Loosdrecht

19:30 Dinner

Wednesday, August 27

Oral Session (Chair, Ibragimova):

09:00-10:00	Abd-Elmeguid (Tutorial): Some Experimental Aspects of High Pressure Spectroscopy

10:00-10:30 Tea/Coffee

Oral Session (Chair, Kugel):

10:30-11:00	Spalek
11:00-11:30	Tripathi
11:30-11:50	Imboden
11:50-12:10	Gehring

Lunch

16:00-16:30 Tea/Coffee

16:30-17:30 Discussion Session

17:30-19:00 Poster Session II

19:30 Dinner

Thursday, August 28

09:00-10:00 Conference Summary

10:00-10:30 Tea/Coffee break

10:30-11:00 Closing

Lunch

Departure

ABSTRACTS

High Pressure Studies on Yb Heavy Fermion Systems: A Key for Understanding Novel Ground State Properties Near a Quantum Critical Point

Mohsen M. Abd-Elmeguid

II. Physikalisches Institut, Universität zu Köln, Zülpicher Str 77, D-50937 Köln, Germany

The discovery that some Yb intermetallic compounds reveal many of the interesting Kondo-related properties found in Ce compounds has generated considerable excitement. Towards a better understanding of the ground state properties of this class of materials, we have investigated the effect of pressure on the magnetic and electronic properties of the nonmagnetic (NM) heavy fermion systems located near a magnetic quantum critical point (QCP) (e.g. Yb_2Ni_2Al, $YbCu_2Si_2$ and $YbRh_2Si_2$) using the ^{170}Yb Mössbauer effect, electrical resistance and x-ray diffraction techniques. In all compounds we find microscopic evidence for a pressure-induced phase transition (first-order) from the nonmagnetic state to a magnetically ordered state of Yb local moments.

In the case of $YbRh_2Si_2$, we show that by crossing the QCP spin fluctuations exist up to very high pressures. A new magnetic phase diagram in the (p,T) space is suggested.

Resonances in Trapped 2D and 3D Bose-Einstein Condensates Under Periodically Varying Atomic Scattering Length

F.Kh. Abdullaev [1], R.M. Galimzyanov [1] and J.C. Bronski [2]

[1] Physical-Technical Institute of Uzbek Academy of Sciences, Uzbekistan
[2] Department of Mathematics, University of Illinois at Urbana-Champaign, USA

In this work we study analytically and numerically nonlinear oscillations and associated resonances of 2D and 3D radial symmetric Bose-Einstein condensates under periodic variation in time of the atomic scattering length. The time-dependent variational approach is used for the analysis of the characteristics of nonlinear resonances in the oscillations of the condensate.

For the case of a 3D Bose-Einstein condensate the formula for the critical driving leading to the destruction of the attractive condensate at the fixed number of atoms is derived.

Interplay of Antiferromagnetism and Superconductivity in Disordered Metals

J M Acton and B D Simons

Theory of Condensed Matter Group Cavendish Laboratory, University of Cambridge

Over recent years, efforts have been made to explore the effect of weak disorder on the transport and spectroscopic properties of magnetic metals in the vicinity of a quantum critical point. These investigations have generated a variety of predictions from glass-like and Griffiths phase phenomena to disorder dominated critical behaviour. Here we explore the interplay of superconductivity and antiferromagnetism in a weakly disordered environment. As a prototype system, we consider a metal close to both spin density wave and singlet s-wave superconducting instabilities.

Magneto-Optical Properties of Semiconductors

Amonov, M.Sharipov

Bukhara State University

Magneto-optical properties of semiconductors is valued.

2DHG Spin-Orbit Effects in $Si_{0.05}Ge_{0.95}$ Asymmetrically Boron-Doped Quantum Well

V.V. Andrievskii, I.B. Berkutov and Yu.F. Komnik

B.Verkin Institute for Low Temperature Physics and Engineering of NAS of Ukraine, 47, Lenin Ave. Kharkov, 310164, Ukraine

There has been an increasing interest in zero-magnetic-field spin splitting in two dimensional (2D) systems, which leads to essential spin-orbit interaction. The resistivity, magnetoresistance (MR) and Hall coefficient of *Si-SiGe-cap* / $Si_{0.37}Ge_{0.63}$ < B > / *SiGe-spacer* / $Si_{0.05}Ge_{0.95}$ - *QW with 2DHG* / $Si_{0.37}Ge_{0.63}$ / *SiGe*} linearly graded buffer y = 0.05-0.63 / *n-Si*(001) heterostructure had been analyzed in the temperature range 0.335 -30 K and under magnetic fields up to 11 T [1]. The magnetic quantum effects, such as the Shubnikov-de Haas oscillations (SdH), occur in high magnetic fields. The SdH oscillations analysis made it possible to get following values for 2DHG concentration and the effective mass: $p_{SdH} = 1.62 \times 10^{12}$ cm^{-2} ($p_H = 2.8 \times 10^{12}$cm^{-2} obtained from the Hall coefficient) and $m^* = 0.156 \cdot m_0$. Using the measured value of Hall mobility $\mu = 4.1 \times 10^3 \cdot$ cm^2/($V \cdot s$) and the values of m^* and \$ p_H we obtained Fermi wave-vector $k_F = 4.27 \times 10^6$ cm^{-1}, Fermi energy E_F =44.2 meV and 2DHG mean free path length $l = 1.911 \times 10^{-5}$ cm. The fast increasing of MR can be observed in weak magnetic fields (≤ 0.6 T) and some new feature appears on background of positive MR, disappearing at T > 7 K. This feature can be connected with weak localization effects of the 2DHG, with close values of spin-orbit scattering time τ_{SO} and inelastic scattering time τ_φ. One can suggest that the spin states are splitted under influence of high vertical electric field, due to asymmetrical doping (Rashba mechanism). The magnetic field dependence of quantum corrections to the resistivity allowed us to estimate τ_φ and $\tau_{SO.}$ When temperature increasing from 0.35 to 0.78 K the value of τ_φ decreases from ~ 3×10^{-12} sec to ~9×10^{-13} sec and $\tau_{SO} = 8.5 \times 10^{-13}$ sec is temperature independent. The latter value was used to estimate the value of spin splitting at B=0. These results suggest that high germanium content p-SiGe/Si-based heterostructures are promising for spintronics applications.

Acknowlegements: M. Myronov, O.A. Mironov (University of Warwick, Coventry,UK) for all experimental results supplied, T. Hackbarth for SiGe sample growth.

1. M. Myronov, PhD Thesis, The University of Warwick, Coventry, UK, 2001

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Spin-Orbit Effects in $Si_{0.05}Ge_{0.95}$ Quantum Well

V.V. Andrievskii, Yu.F. Komnik, I.B. Berkutov

B.Verkin Institute for Low Temperature Physics and Engineering of NAS of Ukraine,
47, Lenin Ave. Kharkov, 310164, Ukraine

There has been an increasing interest in zero-magnetic-field spin splitting in two dimensional (2D) systems, which leads to essential spin-orbit interaction. The resistivity, magnetoresistance (MR) and Hall coefficient of *Si-SiGe-cap*/*SiGe-spacer* / $Si_{0.37}Ge_{0.63}$ <B> /$Si_{0.05}Ge_{0.95}$ - QW with 2DHG /$Si_{0.37}Ge_{0.63}$ / *SiGe* linearly graded buffer y = 0.05-0.63 /*n-Si*(001) heterostructure had been analyzed in the temperature range 0.335-30 K and under magnetic fields up to 6 T [1]. The magnetic quantum effects, such as the Shubnikov-de Haas oscillations (ShdH), occur in high magnetic fields. The ShdH oscillations analysis made it possible to get following values for 2DHG concentration and the effective mass: p_{SdH} =1.62x10^{12} cm^{-2} which is close to p_H =1.76x10^{12}cm^{-2} obtained from the Hall coefficient and m^* =0.156·m$_0$. Using the measured value of Hall mobility μ = 6.81x10^3 cm^2/(V·s) and the values of m^* and p_{SdH} we obtained Fermi wave-vector k_F = 3.32x10^6 cm^{-1}, Fermi energy E_F =27.0 meV and hole mean free pass l = 1.49x10^{-5} cm. The fast increasing of magnetoresistance can be observed in weak magnetic fields (≤ 6T) and the some new feature appears on background of positive MR, disappearing at T > 7K.

This feature can be connected with weak localization effects of the 2DHG, with close values of spin-orbit scattering time τ_{SO}. One can suggest that the spin states are splitted under influence of high vertical electric field, due to asymmetrical doping (Rashba mechanism). The magnetic field dependence of quantum corrections to the resistivity allowed us to estimate τ_φ and τ_{SO}. When temperature increasing from 0.35 to 0.78 K the value of τ_φ decreases from ~ 3x10^{-12} sec to ~9x10^{-13} sec and τ_{SO} = 8.5x10^{-13} sec is temperature independent. The latter value was used to estimate the value of spin splitting at B=0. These results suggest that high germanium content p-SiGe/Si-based heterostructures are promising for spintronics applications.

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1. M. Myronov, PhD Thesis, The University of Warwick, Coventry, UK, 2001.

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Development of Miniature Hydrostatic Pressure Cell for Closed Cycle Refrigerator System

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High Pressure Low Temperature Lab, Department of Physics,
Bharathidasan University, Tiruchirappalli, India.

* Reader in Physics, ** Research Scholar

We have developed miniature piston - cylinder clamp type hydrostatic pressure cell for Closed Cycle Refrigerator system. The pressure cell is made of high purity copper and Ni- Cr- Al alloy with 20mm as a outer diameter and 4mm as a inner diameter. The cell has been calibrated with NH_4F, Mn & V_3Si. Variation of resistivity as a function of pressure for few Superconducting and CMR materials will be discussed.

Opportunity of Definition of EXCITON DIFFUSION Length in Semiconductors on a Data of PHOTOMAGNETIC Measurements

I.G. Atabaev, N.A. Matchanov, E.N. Bakhranov, T.M.Saliev, M. Khojiev

Physical-Technical Institute of Science Academy of Uzbekistan
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Lifetime and diffusion length of excitons are the major characteristics determining the conditions of formation of the excitonic condensate in solids.

Usually these characteristics are defined on a data of optical measurements. Electrical charge of exciton is zero and the electrical measurements can not be used for definition their diffusion length and life time. Though it is possible to conduct valuation of these characteristics from photo-electric properties of solar cells and other semiconductor devices.

In presented work a method of valuation of exciton diffusion length in semiconductors is offered: Well known, excitons reaching the area of p-n junction disintegrate on free current carriers and give the some contribution to magnitude of photocurrent I_{photo}. Under the magnetic field energy of exciton formations varies, and photocurrent I_{photo}^{H} of p-n junction will be determined only by free current carriers (electrons and holes).

The analysis has shown, that the $\Delta I = (I_{photo} - I_{photo}^{H})$ of p-n junction mainly depends on diffusion length of current carriers($L_{e,h}$) and excitons ($L_{exciton}$) and depth of p-n junction. If the $L_{exciton} > L_{e,h}$ photocurrent of p-n junction should decrease.

The measurements were conducted on solar cells on the basis of Silicon and Gallium Arsenic. Magnetic field was $5{,}5\ 10^{3}$ H. The light excitation was conducted by bulb and semiconductor laser (1 mWatt, λ= 630-680 nm). Quantity of excitons reached junction area and their diffusion length in Si and GaAs is evaluated on photomagnetic measurements data.

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Theoretical Investigation of Photoelastic Properties Multiple Quantum Well Structures in the Region of Exciton Resonances Taking Into Account Well Width

R.A.Ayukhanov [1] and G.N.Shkerdin [2]

[1] Physical-Technical Institute of Uzbek Academy of Sciences,Tashkent, Uzbekistan
[2] Institute of Radio Engeneering of RAS. Fryazino, Moscow region, Russia

For estimation of photoelastic coefficients (PC) in the multiple quantum well structures (MQWS) in the exciton resonances region the ideal two-dimensional exciton approach was used. However for more precisely calculation of dielectric function (DF) and PC it is necessary to take into account the final width of the quantum well. It was made in this work.

The analytical expression obtained for linear DF and PC in the MQWS in the region of resonance of ground exciton state was compared with the same value for three-dimensional crystal. It is shown that in case of MQWS the value of PC $A = 2a_B^3/L\lambda^2$ times as much, a - Bohr radius of three-dimensional exciton, L-the period of MQWS, λ - the trial parameter (the wave function and the energy level of system of interacting electron and hole in the quantum well was calculated by variational method). That is under $2a_B=L$ the value of PC in case of MQWS $A=a^2/\lambda^2$ times as much. For MQWS of system GaAs/$Al_{0.28}Ga_{1-X}$As, width of quantum well ~ 10.2 nm, $A \sim 1.8$.

The calculation PC in MQWS system GaAs/$Al_{0.28}Ga_{1-X}$As in the region of the wave-length edge of the exciton resonance formed by electron and heavy hole was carried out. It is shown, that the PC 4 times as much of the same value for three-dimensional GaAs in non-resonant region of frequency. The PC have such big values even at room temperatures because of the fact that in MQWS augmentation of exciton Ridberg constant leads to development of exciton peaks of strongly pronounced steepness. The strong changes in the absorption coefficient (and the refraction coefficient) are enough for arising of large PC already on the broad curve of the exciton absorption and of the transparence region.

It is possible the real using of MQWS as acoustic optical material with a high magnitudes of PC and M_2 in the frequency region near the wave-length edge of the quasi-two-dimensional exciton resonances.

Nonlinear Polarization Rotation Effect Of A Laser Beam In Ruby Crystals

S.A. Bakhramov, A.M. Kokhkharov, O.R. Parpiev, E.V. Vaganov, K.G. Shaynurova

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Recently[1] at passage powerful elliptical polarized laser beam through water solutions of amino-acids along with the natural optical rotation, the nonlinear polarization rotation effect was also observed. In this work we report the results of first experimental observation and investigation of similar resonant nonlinear polarization rotation effect (NPR-effect) in ruby ($Al_2O_3:Cr^{3+}$) crystals. In experiments the pulse of Q-switch ruby laser (λ=694.3 nm, intensity $I_L \approx 20$ MW/cm^2 and pulse duration t_p = 25 nsec) was passed through a Glan-polarizer and quarter–wave plate before it was directed into a $Al_2O_3:Cr^{3+}$ crystal. The used crystal samples (length~120 mm, the mass concentration of impure ions Cr^{3+} ~0.02÷0.05%) were established inside of a oven with optical windows. We made experiments in a frequency vicinity of one-photon transition $\bar{E} - {}^4A_2$ of the Cr^{3+} of the crystal $Al_2O_3:Cr^{3+}$. In experiments the frequency of incident laser radiation was fixed, but the frequency of transition $\bar{E} - {}^4A_2$ was detuned by changing of the temperature of a $Al_2O_3:Cr^{3+}$ crystals. Exact resonance was at the temperature ~12°C. The experimental curves of the dependence of nonlinear polarization rotation angle φ on the temperature of a $Al_2O_3:Cr^{3+}$-crystal samples and frequency detuning from resonance $\bar{E} - {}^4A_2$ transition are presented in Fig.1. A dispersion curves of dependence $\varphi(\delta-\delta_0)$ have resonant behaviour.

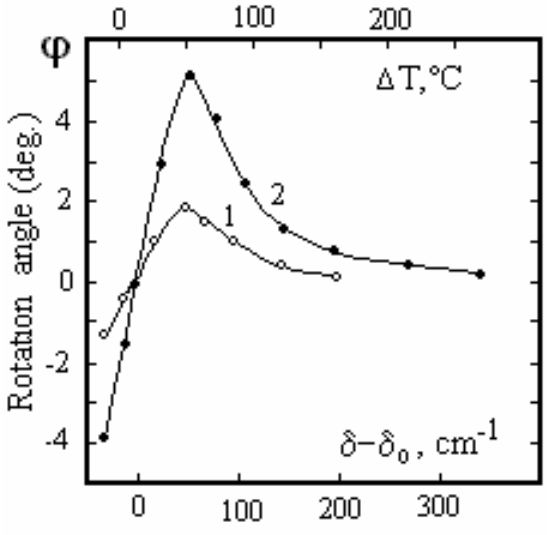

Fig.1. Nonlinear polarization rotation angle as a function of frequency detuning $\delta-\delta_0$, δ_0=13.6 cm^{-1} and $Al_2O_3:Cr^{3+}$-crystal temperature ΔT=T-20°C. The laser beam intensity $I_L \approx 20$ MW/cm^2 and ellipticity $\theta \approx 10^{-3}$, Cr^{3+} mass concentrations – 0,023% (curve 1) and 0,05% (curve 2).

The polarization rotation angle φ at fixed temperature of crystal sample depends also on intensity and on ellipticity of incident laser beam. That testifies to nonlinear nature of observed polarization rotation effect. The observed phenomenon of rotation of polarization ellipse cannot be explained by presence an anisotropy in $Al_2O_3:Cr^{3+}$–crystal samples, which can result only in change of beam ellipticity. It is impossible also due to magneto-optical Faraday effect, because in our experiments we did not apply an external magnetic field to the crystal samples and finally the observed effect has resonant character. We would remind, that the nonlinear polarization rotation effect plays important role in powerful solid-state laser systems with amplifiers as a factor which may limit efficiency of amplification of laser radiation. The mechanism of nonlinear resonant polarization rotation effect in impure crystals is discussed.

Bakhramov S.A., Kokhkharov A.M., Kahharov M.M., Nonlinear optical activity of biological molecules", Izvestija of Russia Academy Sciences (ser.Physics), 1999, Vol.63, No.6 P.1132-1137.

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Nonlinear Resonant Polarization Rotation Effect of a Laser Beam in Ruby Crystals

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In last few years for study of nonlinear gyrotropy of condensed media and free-atoms were developed different theoretical and experimental methods based on use of many local and nonlocal linear electro-optics or nonlinear effects [1,2]. These methods allow carrying out measurements both in the bulk and at the surfaces of researched medium.

The first observation of intensity-dependent changes in the real-part refractive indexes of simple nongyrotropic liquids (nonlinear gyrotropy effect in liquids) was reported [3]. The similar nonlinear polarization rotation effect of laser radiation in the saturated atomic gases of alkaline metals in the vicinity of one photon resonant transitions was observed for the first time [4] and later was in details investigated [5]. The nonlinear rotation of the three-dimensional solitons around the beam axis in alkali atomic vapors was demonstrated [6].

Recently [7,8] at passage powerful elliptical polarized laser beam through water solutions of natural amino acids (Ala-alanine, Glu-glutamine acid and Gly-glycine), along with the natural optical rotation, the nonlinear polarization rotation effect was also observed. The direction of nonlinear rotation was coincided with the direction of natural optical rotation of the linearly polarized beam, and the nonlinear rotation value has grown with increase of laser intensity and ellipticity.

In this work we report the results of experimental observation and investigation of similar nonlinear polarization rotation effect in the impure crystals $Al_2O_3:Cr^{3+}$. The experimental setup is similar to that in ref. [8].

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Electromagnetism at Low Energies: Pions versus Magnons

Oliver Bar [1], Matthias Imboden [2], Uwe-Jens Wiese [2]

[1] Institute of Physics, University of Tsukuba, Tsukuba, Japan
[2] University of Bern, Institute of Theoretical Physics

The low energy dynamics of pions in (3+1) dimensions and magnons in (2+1) dimensions, which are the Goldstone Bosons of the strong interactions and of magnetism, respectively, are analogous in many ways. The electroweak interactions of pions result from gauging an $SU(2)_L \times U(1)_Y$ symmetry which then breaks down to the $U(1)_{em}$ gauge symmetry of electromagnetism. The electromagnetic interactions of magnons are described by gauging not only $U(1)_{em}$ but also the $SU(2)_s$ spin rotational symmetry. The electromagnetic fields **E** and **B** appear as non-Abelian vector potentials.

In the theory of pions and photons a Goldstone-Wilczek current represents the baryon number of Skyrmions and gives rise to the $\pi^0 \rightarrow \gamma\gamma$ decay. Likewise, if Baby-Skyrmions have electron quantum numbers, magnons will couple to the analogue of a Goldstone-Wilczek current for Baby-Skyrmions. This also includes a vertex for the decay of a magnon into two photons. Analogous to axion-photon conversion in a strong magnetic field, magnon-photon conversion is also possible.

Electroweak instantons give rise to baryon number violating processes that cause the t Hooft anomaly. This provides a decay channel for Skyrmions. There is no corresponding decay cannel for Baby-Skyrmions.

In the pion theory the number of flavors can be increased resulting in additional massless mesons. This leads to the topological Wess-Zumino-Witten term that contributes to the $\pi^0 \rightarrow \gamma\gamma$ decay channel. There is a mathematical analogue for magnons with larger symmetry groups. Again an analogue of the Wess-Zumino-Witten term can be found. In the pion theory the prefactor of the Wess-Zumino-Witten term is quantized and equal to the number of quark colors. In the magnon theory, on the other hand, the prefactor represents the anyon statistics parameter θ and is thus not quantized.

High Pressure Resistivity Measurements of the Itinerant Ferromagnet CoS_2

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The spin-fluctuation model [1] has been used for many years to interpret the behaviour of magnetic d-metals. When the magnetic transition is suppressed to zero temperature at a quantum critical point (QCP), the appearance of non-Fermi liquid behaviour of the thermodynamic and transport properties is predicted within this theory. More recently several of these systems have been found to be metamagnetic, which has generated interest in the connection between quantum criticality and metamagnetism [2].

Cobalt disulphide (CoS_2) is an itinerant ferromagnet with a Curie temperature of T_c = 121 K. It has a cubic crystal structure of the pyrite type and displays full inversion symmetry. High purity single-crystal samples previously used in quantum oscillatory studies are available, making CoS_2 a promising candidate for the investigation of a ferromagnetic quantum phase transition.

Previous work under high pressure and in high magnetic fields [3, 4] has shown that T_c in CoS_2 decreases with the application of pressure and is expected to vanish at $p_c \approx$ 5.6 GPa. The ferromagnetic transition at Tc changes from 2nd to weakly 1st order for $p \geq 0.4$ GPa, where a metamagnetic transition appears just above T_c. Measurements of the electrical resistivity of CoS_2 were performed using a Bridgman anvil cell up to p=10 GPa, i.e. up to and beyond the critical pressure. The magnetic phase diagram was determined in these quasi-hydrostatic measurements by tracking the anomaly in the resistivity at T_c. The anomaly in the resistivity broadens with increasing pressure, in disagreement with previous findings [4]. This effect is speculated to be due to the inherently inhomogenous pressure, transmitted by the solid pressure medium used in the Bridgman technique. The critical pressure of CoS_2 could therefore not be established exactly and was found to be in the vicinity of 8 GPa by extrapolation. It was found that the temperature dependence of the resistivity at low temperatures (200mK-10K) changes from a power-law with exponent n=2 to n<1.7 as the quantum critical point is approached.

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Ice Enabled Quantum Complexity in a Doped Cobalt Oxide

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A recent discovery of superconductivity by Takada et al. [1] in $Na_xCoO_2.yH_2O$, a strongly correlated layered cobalt oxide metal has stimulated experimental and theoretical activity. This oxide, in the absence of the intercalated H_2O does not superconduct; an unusual and unexpected role is played by `ice'. I will review a theoretical model that I have proposed [2] to understand this strongly correlated electronic system and a consequent rich phase diagram. The superconducting state in particular is predicted to be of $d + id$ type. A large dielectric screening provided by the intercalated `ice' layer will be argued [3] to assist the development of superconducting order in the face of a competition from a variety of charge orders.

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Evidence for two electronic components in Na_xCoO_2 (x = 0.7-0.75)

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Thermodynamic and transport measurements on Na_xCoO_2 (x ~ 0.7-0.75) over a wide temperature range reveal broad anomalies between ~180 K and ~300 K, and a strongly enhanced low energy excitation spectrum. This unusual excitation below ~5 K is partially suppressed in a magnetic field, following a T/B scaling. The heat capacity reduction at low T is partially compensated by an increase at higher temperature. The zero-field heat capacity and resistance at low temperature are propotional to T^n with n<1. A quantitative comparison with the magnetoresistance and the thermopower indicates that the low-energy electronic state requires a description beyond the single band model.

Experimental Investigations of Electronic Structure in Correlated Materials

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I will give a tutorial introduction into experimental methods used in contemporary condensed matter physics to probe the electronic structure of correlated materials. The emphasis will be on quantum oscillation, magnetoresistance, and photoemission experiments, with a particular focus on quasi-2D systems including layered cuprate and ruthenate unconventional superconductors. A few worked examples of recent interest will be presented.

Quantum Criticality in Fermionic Superfluids and Emergent Relativity

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Quantum critical points in fermionic superfluids may have universality properties such as a universal velocity scale. Ongoing research on quantum criticality in d- and f-electron materials may help clarify to what extent such such properties are actually realized. Universal quantum critical behavior in fermionic superfluids may also be crucial for the understanding of black hole horizons and elementary particle interactions.

Structure of Chaotic Wave Functions in Multi-well Potentials

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We propose a new approach to investigation of quantum manifestations of classical stochasticity (QMCS) in wave functions structure, which can be realized in potentials with two and more local minima. The main advantage of the proposed approach is the possibility to detect QMCS in comparison not different wave functions, but different parts of the same wave function.

Efficiency of the approach is demonstrated for two potentials: surface quadrupole oscillations and lower umbillic catastrophe D_5.

On the Stability of Quantum Criticality

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We now have several examples of quantum criticality since the discovery of superconductivity on the border of itinerant magnetism. While it is important to find new manifestations of quantum critical phenomena, it is perhaps more pressing to classify what is already known and to find an underlying theme, or the 'big picture'. Using $Sr_3Ru_2O_7$ as a starting point, we find that the criticality is (1) almost predictable, given the structure and dimensionality and (2) not unique. The criticality exists over a large pressure range, reminiscent of several other materials, and suggests a highly anomalous though stable state of matter.

Phase Transition in HTSC Ceramic Y-Ba-Cu-O
Under the Action of the Direct Current

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The precise measurements of an experimental function R(J) were fulfiled in detail in a region of the superconductor-normal metal phase transition (PT) of the Y-Ba-Cu-O high temperature superconducting ceramic. Here R is a resistance, J is a value of direct current. The results were compared to the theoretical function. The experiment has confirmed the theory. PT has three stages that is related with the existance of one-, two- and three – dimensional coordinate spheres characterized by the different values of dimensionaless correlation energy and by the different intervals of critical current's values. It is found that under the action of current's circular magnetic field the region of destruction of two-dimensional correlations has fallen apart into three parts with the close but different values of two-dimensional correlation characteristics. We believe that the observed effect is similar to Zeeman's one in high temperature superconductors which has been observed under the phase transition. By gradual increasing of the current the one-dimensional correlations are destructed in the first place and the three-dimensional ones – in the last place. The inverse sequence was observed in the case of superconductivity destruction under the temperature.

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Superconductivity and Carrier Concentration

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Despite the fact that after the discovering of metal-oxide high-temperature superconductors much effort has been directed to studying their unique physical features, the problem of studying the superconductors with the A15 and B1 structure (as well as other classes) remains actual and topical. Until now there is no clear answer why these metal-oxide superconductors have such high critical temperatures ($T_c \geq$100 K). The results obtained for the materials with the A15, B1 deepen our conceptions of superconductivity and allow us to make some conclusions about the direction of future studies. Further progress in our understanding of the entire phenomenon of superconductivity, increase in the critical superconductor parameters, creation of new superconducting materials, stabilization of their properties require the detailed and comprehensive study of superconductors of a wide variety of types.

The present work is dedicated to studying the connection of the superconducting and electronic characteristics of the compounds with A15, B1 and perovskite-type structures. The critical temperature, T_c, of the superconducting transition, the superconducting energy gap Δ and concentration N of carriers (conduction electrons), the London depth, λ_L, of magnetic field penetration are considered. The study results have demonstrated that there is correlation between T_c, Δ and N. It has been found that the correlation dependence obeys the power law ($T_c \sim N^{2/3}$; $\Delta \sim N^{2/3}$).

For superconductors with high value of T_c the strict theory does not provide sufficiently specific recommendations for the directions of studies. On the basis of the theory only, it is difficult to predict which materials can have high values of critical temperature. In this case it is important to reveal correlation of T_c with different characteristics of superconductors, particularly those that can predict features of materials with high critical temperature.

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Pseudogap Phenomena in High-T_c Cuprates

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Theoretical models and experimental results concerning the pseudogap (PG) state in the underdoped, optimally doped and overdoped high-T_c copper oxides are reviewed and critically analyzed. We discuss the current theoretical understanding of the underline physics of PG phenomena and show that the different competing theoretical models based on the spin-charge separation scenario, precursor superconducting (SC) and antiferromagnetic (AF) fluctuations, Bose-Einstein condensation of real-space pairs, and marginal Fermi-liquid phenomenology are not successful enough in explaining the PG state in these high-T_c superconductors (HTSCs). It has been argued that the existence of the strong electron-phonon interaction in doped HTSCs is fully compatible with many experimental observations and the theoretical models neglecting these important interaction in polar materials do not provide insight into the mechanisms underlying the PG phenomena in underdoped, optimally doped and even overdoped HTSCs. The analyses of a variety of experimental situations indicate that the underdoped and optimally doped HTSCs are characterized by two so-called large and small normal-state PGs which exist in the excitation spectrum of these materials. Special emphasis has been given to the physically relevant (bi)polaronic effects which are responsible for the formation of such two distinct PGs in the underdoped and optimally doped HTSCs with different characteristic energies. It is shown that two types of non-SC energy gaps or pseudogaps are formed well above the SC transition temperature T_c and persist below T_c in the excitation spectrum of these HTSCs. The energy scales and temperature and doping dependencies of these PGs are determined and compared with experimental results. The occurrence of the characteristic temperature T_0 and T^* above T_c is explained by the large polaron model and the non-SC BCS-like pairing model of polarons. One of the PGs is a temperature independent non-pairing (i.e. polaronic) PG opening below T_0, and the other one is a temperature dependent BCS-like pairing PG which appears below the pair formation temperature $T^*<T_0$. It is concluded that the experimentally observed large and small PGs in the underdoped and optimally doped HTSCs are the non-pairing and non-SC (however BCS-like) pairing PGs. Unlike in these HTSCs the only non-pairing PG state in the overdoped HTSCs may exist above T_c.

Charge ordering versus Zener polarons and Possible Ferroelectricity in Manganites

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We consider the conditions of different types of magnetic, charge and orbital orderings in manganites, close to half-doping. We show that the Zener polaron phase is preferable in certain part of the phase diagram. Moreover the novel Zener polaron phase coexists in the large part of the diagram with conventional CE-phase. We show that as a result of the superposition of the two phases the system become ferroelectric.

Nonlinear Optics for the Investigation of Magnetic Structures

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Diffraction experiments with x-rays, electrons and neutrons are powerful tools for studying the structure of matter with neutrons playing a singular role in the investigation of magnetic matter. In practice, however, diffraction experiments are subject to restrictions and auxiliary experiments are needed in order to come to reliable conclusions. In this talk, nonlinear optical methods, and among them especially optical second harmonic generation (SHG) are introduced as powerful complement for the investigation of magnetically ordered materials. The determination of magnetic structures from SHG is based on the relation $P_i(2\omega) = \varepsilon_0 [\chi_{ijk}(i)+\chi_{ijk}(c)]E_j(\omega)E_k(\omega)$ between the induced and experimentally detected nonlinear polarization $P_i(2\omega)$ at frequency 2ω and the electric fields $E_j(\omega)$ and $E_k(\omega)$ of the incident light at frequency ω. $\chi_{ijk}(i)$ and $\chi_{ijk}(c)$ are the components of the nonlinear susceptibility tensors which couple to the crystallographic and magnetic structure, respectively. Therefore the set of non-zero components $\chi_{ijk}(c)$ can be used to reveal the magnetic structure, properties, and interactions of a system [1]. The particular benefit of nonlinear optical experiments for the investigation of magnetic structures are its additional degrees of freedom [2]. Spectroscopy allows to study electronic structures and - contrary to linear optical experiments -distinguish very clearly between transitions of magnetic and nonmagnetic origin. In centrosymmetric compounds SHG in the leading order is restricted to the symmetry-breaking surfaces or interfaces and therefore a highly selective sensor for surface or interface magnetism e.g. in magnetic heterostructures or in metallic thin films. Optical imaging allows to study the magnetic order spatially resolved which opens a path to the investigation of local magnetic phase transitions, phase coexistence or thecorrelation between substrate inhomogeneities and the magnetic state. With use of ultrashort laser pulses it is possible to reveal the spin dynamics of ferro- and antiferromagnets and visualize the temporal evolution of de- and remagnetization processes on the sub-picosecond time scale. Because of the direct access of SHG to the magnetic structure via the van-Neumann principle [1], involvement of additional models for the interpretation of experimental data is unnecessary, so that in compounds with complex frustrated or interacting spin lattices the magnetic structure can be clarified by SHG, whereas attempts with diffraction techniques lead to contradictory conclusions. In antiferromagnets linear magnetooptical effects are too small to be feasible for the investigation of the antiferromagnetic state. Here nonlinear optical techniques are particularly useful since they can lead to antiferromagnetic contributions which are of the same order of magnitude as the crystallographic contributions. In a variety of antiferromagnetic compounds 180° domains, interacting magnetic sublattices, hidden magnetic phase transitions, and a clamping between electric and magnetic domain walls were observed by SHG [3]. In summary the basic nature of the relation between symmetry and magnetism allows to study arbitrary magnetic structures by nonlinear magneto-optics and come to new insights into the physics of the magnetically ordered state.

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The Phases of UPd_3

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UPd_3, which forms in the double hexagonal structure, has localised f electrons that may be understood in terms of crystal field states. It has four quadrupolar phase transitions at temperatures between 7.8K and 4.4K. There have been extensive experimental studies including thermodynamic variables – the entropy and susceptibilities as a function of temperature, structural studies using neutrons and X-rays, and dynamic measurements including inelastic neutron scattering and ultrasonic measurements. In this talk we show that the phase transitions are driven by the electronic states on the quasi-cubic sites where the ground state doublet is coupled to a higher singlet at ~4meV by the quadrupole order parameters and to this singlet and another (higher) one by a magnetic field in the x or y directions. We show that the phase diagram of this three level system is very rich and enables us to identify all the phases involved and to understand why they occur. In addition we show that UPd_2 certainly shows dynamic quadrupole effects.

The Phase Transition in a Material Where the Magnetic Ordering Transition is Driven to Zero by Applied Pressure

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We use Landau theory arguments to show that if the transition temperature varies with pressure in the critical region like $\left(1-\frac{p}{p_c}\right)^{\xi}$ where $\zeta<1$ the derivative will diverge as $p \rightarrow p_c$. This will give a first order transition. We evaluate the critical temperature and pressure for this to occur and compare with experiment for MnSi and some other materials.

Features of Optical Polarized Absorption in Rare-Earth

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The polarization spectra of optical absorption the 4f-4f transition $^6H_{15/2} \rightarrow {}^6F_{3/2}$ and $^6H_{15/2} \rightarrow {}^6F_{5/2}$ in the rare-earth orthoaluminate $DyAlO_3$ have been experimentally studied at the temperature T=78K. It has been shown that non-trivial character of the polarization absorption spectra anisotropy for low temperatures can be explained by a contribution of the J-J "mixing" mechanism for excited multiplets of the ground $^4f_9$ configuration of the Dy^{3+} ion in the low-symmetry crystalline field (C_s group) in the orthoaluminate structure [1]. Moreover, a detailed crystal-field splitting analysis is reported for energy levels of the Dy^{3+} ion in crystals of $YAlO_3$ and $DyAlO_3$ orthoaluminates. A parameterized Hamiltonian, including Coulombic, spin-orbit, configuration interaction and crystal-field terms in Cs symmetry, was diagonalized for the ^6H_J, ^6F_J , ^4F_J and , ^4G_J states. Initial sets of crystal-field parameters were determined from lattice-sum calculations and the three-parameter theory. Considerably J-J "mixing is found for states having nearly the same energy such as the manifolds $^6F_{11/2}$, $^6H_{9/2}$ and $^6F_{9/2}$, $^6H_{7/2}$ [2]. It is interesting to note, that even electronic states that are well separated from each other in energy show sufficient J-J "mixing" to explain the polarized absorption [1] and Zeeman effects [3] that involve transitions from the nearly "pure"(less than 0.2% J-J "mixing") ground state $^6F_{15/2}$ to excited states such as $^6F_{5/2}$ and $^6F_{3/2}$.

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Radiation Induced Sub-Micron Precipitates

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Radiation-induced phase transformations in carbon (graphite, diamond), SiO_2 (quartz - silica glass) and Al_2O_3 (sapphire - alumina) have been studied for a long time and the related precipitate formation mechanism was proved recently. The formation of nano-size diamond "onions" at high-energy C_{60} fullerene molecule beams was reported five years ago. Optical scattering/absorption technique is limited by the wavelength of ~300 nm. Special X-ray and electron diffraction analysis has been elaborated for approaching to this difficult problem with the wavelength limit as good as < 1 nm. A few interesting examples are discussed below.

A long term gamma-irradiation of non-stoichiometric ZnSe(Te) and ZnSe(O) was found to result in noticeable change of the ratio Zn:Se and formation of sub-micron ZnO film on the crystal surface. The mechanism is radiolytic - rupture of Zn-Se bond followed by Se loss and Zn oxidation. Such chemical decomposition takes place on the surface layer and forms a sub-micron cellular texture. The irradiation induced sub-micron ZnO film reveals itself as additional bands in optical spectra and causes a significant shortening of luminescence kinetics. This is very promising feature for elaboration of fast radiation detectors and solar cells based on ZnSe-ZnO semiconducting structures.

Gamma-irradiation of wet porous glass stimulated significantly the electric (including proton) conductivity because of sub-micron porosity development and change of inner surface state under radiolytic water decomposition. Such enhancement of the proton conductivity of gamma-irradiated porous glasses makes them attractive for application as electrodes in hydrogen energy systems. Bulk electric conductivity measured in porous ceramics and glasses should be considered as a surface conductivity by nature. This part of researches was done under the STCU project Uz23j.

Gamma-irradiation of graphite at elevated temperatures and pressure revealed some structure modification as sub-micron diamond precipitates similar to the effect of diamond nano-crystallites formation from fullerene molecules.

The work was done by the grant F2.1.2.

Electronic Properties of Charged Interfaces With a Perovskite Type Transition Metal Oxides

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$SrTiO_3$ is widely used as one of the most important bulk substrates for epitaxial syntheses of oxide thin films. Thus, to establish a method of the field-effect doping to $SrTiO_3$ is believed to open the door towards the future oxide electronics.

We have had two complementary approaches to fabricate FET with a $SrTiO_3$ channel. One effort was dedicated on the so-called dry process: a method of the device fabrication which uses stencil masks made of thin metal plates. The other effort was spent on the so-called wet process: a widely used process in contemporary semiconductor-device production lines. The dry process produced an exemplary FET device of $SrTiO_3$ showing a spectacular saturation of the drain current, as well as the large on-off ratio over 100, though the temperature dependence of the field-effect mobility was an activation-type, and thus the device did not work below 150K. Hence the low temperature behaviours below 30K were explored on the wet-process device. Since the carriers are frozen out at low temperatures, the Schottky barriers at the channel/electrodes interface becomes so high to make an injection of carriers from the electrodes difficult. However, since the mobility is so high at the low temperature, once the carrier injection was bulldozed in any methods, the conduction at the channel becomes extremely enhanced. The resulting metallic state at 1.9K showed peculiar characteristics accompanied by a hysteresis reflecting the electronic inhomogeneity of the system; a research along the line is now in progress, and the details will be given in the talk.

Effect of Gamma-irradiation on Structure Transformations of Perovskite Phase of YBaCuO

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Cubic perovskite phase [(Y,Ba)CuO_{3-D}/3]3 was reported recently to be metastable and transformed into the orthorhombic phase YBa_2Cu3O_{7-d} with the T_c ~90 K. Gamma-irradiation of ^{60}Co was found to stabilize the super-conducting structure of YBaCuO ceramics and improve transport characteristics. The ceramic samples of cubic phase with D ~ 0.08 and a_c = 0.4058 nm were gamma- irradiated to doses 103-105 Gy at 320 K, and the structure was analyzed with the improved X-ray difractometer at Cuka *l*= 0.1542 nm. The specific resistivity was taken in the range of 77-300 K and had a mixed metal-semiconductor character r(T) ~ 8.6 - 8.7 x 10^{-2} Ohm cm within 100-300 K. There occurred a good splitting of the main structure lines (100), (200), (210), (211) and (310) of the perovskite phase, except (111) and (222) reflections in the X-diffraction spectrum of the sample irradiated to 103 Gy. Besides, there were several reflections from a phase of less symmetry than that of perovskite one. While the spectrum of the sample irradiated to 104 Gy corresponded completely to the orthorhombic phase $YBa_2Cu_3O_{7-d}$ with d ~ 0.06, a_r = 0.3826, b_r = 0.3891, c_r = 1.1677 nm, and T_c ~ 91 K. Thus, the gamma-irradiation causes degradation of the perovskite phase into pure superconducting phase $YBa_2Cu_3O_{6.94}$ by means of the thermal radiation enhanced oxygen diffusion and desorption.

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Superstructures in Oxides

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In many transition oxides there appear different types of superstructures due to magnetic, charge and orbital ordering. In this talk I will describe some of the recent hot issue in this field, concentrating on the interplay between different degrees of freedom. In particular, the possibility to describe these superstructures proceeding from the band picture will be discussed. Specific features of orbital ordering in frustrated systems will be addressed. In conclusion, I will discuss several issues connected with the multiferroic behaviour of some of these materials, especially the interplay of magnetic and charge ordering with the ferroelectricity.

k-(BEDT-TTF)$_2$Cu(NCS)$_2$: Comparative Analysis of T_c and Magnetoresistive Measurements under Pressure

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k-(BEDT-TTF)$_2$Cu(NCS)$_2$ is one of the best characterized organic superconductors. The resemblance of its pressure-temperature phase diagram to that of the carrier-density-temperature phase diagram in cuprate superconductors has frequently been taken as evidence for similar interaction mechanisms governing superconductivity, even though direct evidence for a correlation between carrier density and T_c in organic superconductors had been missing. We have performed and compared several magnetoresistive as well as ac-susceptibility measurements under pressure on single crystals of k-(BEDT-TTF)$_2$Cu(NCS)$_2$ with different isotopical composition. In contrast to earlier reports*, the isotopical composition of this k-(BEDT-TTF)$_2$Cu(NCS)$_2$ is irrelevant to the pressure dependence of the superconducting state. In general, pressure on k-(BEDT-TTF)$_2$Cu(NCS)$_2$ is seen to decrease T_c and to increase the quasi-2 dimensional Fermi surface area. The exact pressure dependence, however, seems to be strongly influenced by the pressure technique used. However, the apparent divergence of the reported pressure dependences in k-(BEDT-TTF)$_2$Cu(NCS)$_2$ converges into one dependence of T_c against the carrier concentration of the quasi-two dimensional Fermi surface. Pressure in k-(BEDT-TTF)$_2$Cu(NCS)$_2$ is seen to transfer carriers from the quasi-1-dimensional to the quasi-2-dimensional Fermi surface section. The present results point to a strong correlation between T_c and the quasi-2 dimensional carrier concentration in an organic superconductor.

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Nanoscale Phase Separation and Electron Transport in Manganites and Related Compounds

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The interplay between charge ordering (CO), magnetic ordering, and the tendency toward phase separation, which plays an essential role in the physics of manganites and related materials, is analyzed. The analysis is based on a simple model of CO is considered. It takes into account both the Coulomb repulsion at neighboring sites responsible for CO and the essential magnetic interactions (the strong Hund-rule onsite coupling and the weaker intersite antiferromagnetic exchange). It is shown explicitly that at any deviation from half-filling ($n \neq 1/2$) the system is unstable with respect to phase separation into the regions corresponding to CO $n = 1/2$ and metallic regions with smaller electron or hole density. Possible structure of this phase-separated state (metallic droplets in the CO matrix) is discussed. We estimate the parameters of these droplets and construct the phase diagram reproducing the main features observed in real manganites.

Based on the same physical picture, we calculate the conductivity and noise spectrum for the phase-separated state. The system is considered to be far from the percolation transition into a metallic state. The charge transfer is assumed to occur due to the electron tunneling from one droplet to another through the insulating medium. As a result of this tunneling, the droplets acquire or loose extra electrons forming metastable two-electron and empty states. In the framework of this approach, explicit expressions for dc conductivity and noise power of the system are derived. It is shown that the noise spectrum has nearly $1/f$ form in the low-frequency range. The phase separation ensures the large noise magnitude as compared to the homogeneous materials.

In the framework of such a model, the magnetoresistance is determined both by the increase in the volume of the metallic phase and by the change in the electron hopping probability. We demonstrate that the low-field magnetoresistance is proportional to H^2 and may decrease with temperature as T^{-m}, where m varies from 1 up to 5 depending on parameters of the system. In the high-field limit, the tunneling magnetoresistance can grow exponentially.

Superconductivity and Magnetism in Heterometallic Fullerides of Transition Metals

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Heterometallic fullerides with composition KM_2C_{60} or K_2MC_{60} were synthesized by exchange chemical reactions of K_5C_{60} or K_4C_{60} with chlorides of metals Fe and Cu groups. As an example the synthesis of $K_2Fe^{+3}C_{60}$,$KFe_2^{+2}C_{60}$ and $K_2Ni^{+2}C_{60}$ may be described by reactions $K_5C_{60}+Fe^{+3}Cl_3=K_2Fe^{+3}C_{60}+3KCl$; $K_5C_{60}+2Fe_2^{+2}Cl_2 = K_2Fe_2^{+2}C_{60}+4KCl$. X-ray monochromatic Laue diffraction data pointed out the fcc lattice in the investigated samples. Parameter a of fcc lattice in synthesized heterofullerides is less than the value of a in K_3C_{60}, synthesized under the same conditions. It seems to be reasonable because the dimensions of ions for metals of Fe and Cu groups are less than potassium, hence metals were intercalated into fulleride lattice. We used laser induced ion mass spectrometry (LIMS) analysis with Q-switched Nd-YAG laser (lambda=266 nm, tau=8-10 ns) with power density on the sample surface 10^8-10^{11} W/cm^2. According to these data the structure of C_{60} molecule in the synthesized heterofullerides is the same as in the host potassium fulleride. Magnetic susceptibility measurements showed that exchange reaction of K_3C_{60} with Cu^{+1} chloride and Ag^{+1} chloride did not produce superconducting heterometallic fullerides. This reaction reduces metal down to zero-valence state and produces its own phase. Heterometallic fullerides with composition $K_2Co^{+2}C_{60}$ and $KM_2^{+2}C_{60}$ (M=Co, Ni, Fe) also are not superconductors. Heterometallic fullerides K_2MC_{60} with M=Cu^{+2}, Fe^{+2}, Fe^{+3} and Ni^{+2} appeared to be superconductors with T_c =13.9-16.5 K. Heterometallic fullerides have been investigated by X-ray diffraction, electron paramagnetic resonance, Raman and Mossbauer spectroscopy. Low temperature magnetization and susceptibility measurements also have been carried out. Mossbauer spectrum is very similar for $K_2Fe^{+2}C_{60}$ and $K_2Fe^{+3}C_{60}$ fullerides. The spectrum consists of two different signals. The large width of each line is due to quadrupole splitting of the signals (delta=0.71 mm/s for the first signal and delta=0.86 mm/s for the second). The isotopic shift (IS) of the first signal is typical for Fe^0 and IS of the second one is very close to Fe^{+3}. Thus we suppose that iron intercalates fulleride with valences 0 and +3. Quadrupole splitting can be attributed to the presence of Fe in two inequivalent positions in fullerides. The electron paramagnetic resonance (EPR) spectrum for K_2FeC_{60} has almost ideal Lorentzian shape and is essentially broader in Fe-containing compound than in K_3C_{60}. The amplitude of curve decreases with the increasing of temperature, while the width of the resonance increases. The intercalation of Fe causes the strong interaction between magnetic moments in fulleride. Spins in fulleride are ordered and observed EPR resonance is a ferromagnetic resonance. In $K_2Fe^{+3}C_{60}$ magnetization curves typical for ferromagnetic was observed. Raman spectra measured in K_2FeC_{60} shows lines the position of which is strongly correlated with the state of Fe in initial salt used for synthesis.

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Magnetic Field Induced Antiferromagnetic Order in the Vortex Core of HTSC Studied by Spatially-Resolved NMR

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The microscopic structure of vortex core turns out to be a very interesting subject of High-T_c superconductors (HTSC), since many unexpected behaviors have been observed so far. A new class of theories based on the *t-J* and *SO*(5) models have pointed out that the antiferromagnetism arising from the strong electron correlations is very important for accounting the vortex core structure, and that the enhanced antiferromagnetism can appear in the vortex core. Therefore, spatially-resolved probes which are sensitive to the magnetic excitations in the vortex state is strongly desired. Recent experimental and theoretical NMR studies have established that the spatial dependence of nuclear spin-lattice relaxation rate, T_1^{-1} in the vortex state serves as a probe for the spatially different low energy excitation spectrum in HTSC. We have reported the spatially-resolved NMR of underdoped ^{17}O in $YBa_2Cu_4O_8$ (T_c=85K). [1]

Here, we will report spatially-resolved $^{205}T_1^{-1}$ of nearly optimal-doped $Tl_2Ba_2CuO_6$ (T_c=85K). T_1^{-1} at the Tl site can monitor AF fluctuations sensitively, because the Tl atoms are located just above the Cu atom, and hence there exist large transferred hyperfine interactions between the Tl and the Cu site through apical oxygen. $^{205}T_1^{-1}$ in the vortex core is enhanced almost by two orders larger than that of the superconducting region. Together with the characteristic behavior of the recovery curve of nuclear magnetization and anomalous spectrum broadening at low temperature, we show clearly evidences of the antiferromagnetic vortex core in $Tl_2Ba_2CuO_6$. [2] We will present also results of the external field dependence of the antiferromagnetism in the vortex core of HTSC.

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Electronic and Spin Inhomogeneities in Correlated Oxides

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Abstract not available.

On The $T^{3/2}$ Resistivity on the Border of Magnetic Long-Range Order

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The temperature dependence of the resistivity is usually found to be anomalous in the vicinity of a critical lattice density or electronic density n_c, where the Curie temperature or Néel temperature vanishes. Surprisingly, anomalous forms of the resistivity are observed not only where the average ordered moment appears to vanish continuously at n_c, but also where it changes abruptly, i.e., where the magnetic transition is first order.

We review examples in particular of a $T^{3/2}$ form of the resistivity observed on the border of first order ferromagnetic and antiferromagnetic transitions in pure metallic compounds and of first order Mott transitions in stoichiometric oxides and sulphides. Proposals for the possible origins of the $T^{3/2}$ resistivity in these systems will be outlined and considered.

Yellow Excitons in Cuprous Oxide

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High density excitonic gases in semiconducting materials form promising models systems to explore the dynamics of Mott transitions and Bose-Einstein condensation, as well as the fundamental properties of bosonic matter at easily accessible temperatures. Although cuprous oxide has been intensively studied over the past few decades, attempts to achieve Bose-Einstein condensation have failed so far. We propose a novel method for the creation of a high density yellow exciton gas in cuprous oxide through the initial excitation of blue excitons via a 2 photon process. This method has several advantages over the usual one photon approaches in that it creates a more uniform exciton gas, having a lower temperature, and having a higher relative occupation of the low kinetic energy states. We have studied the thus created exciton gas using time resolved recombination luminescence (ortho-exciton) as well as exciton absorption spectroscopy (para-exciton). In view of the very long lifetime (milliseconds), the para-exciton is a promising candidate for a study of(quantum) phase transition of yellow excitons.

Fluctuation Corrections to Ultrasound Attenuation in Layered Organic Superconductors

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We consider the temperature dependence of the sound attenuation and sound velocity in layered impure metals due to superconducting fluctuations of the order parameter above the critical temperature. The temperature dependence of the fluctuation correction to the sound attenuation is weaker than the corresponding correction to the conductivity. Nevertheless, the sensitivity of new ultrasonic experiments on layered organic conductors should make these measurable.

Octopole Magnetism in a Fe_{30} Nanocluster

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Multipole expansion of the electrical field generated by a number of electrical charges has been widely used in theoretical physics. However, multipole expansion of magnetic fields generated by a system of permanent currents is less known.

Spin systems of finite sizes and magnetic molecules ($Mn_{12}Ac$, V_{15}, Fe_8, Fe_{10}, Fe_{30} etc.) in particular are natural objects for application of the multipole expansion technique. The magnetic molecules have attracted great attention from the point of view of fundamental problems of quantum mechanics in general and the theory of magnetism in particular as well as nanotechnology and microelectron applications (for example, as model systems for quantum informatics) in recent years. The molecules are large organic molecular complexes with the weight of approximately 10^3 atomic mass units. The magnetic ions, such as Fe, Mn, V, etc. embedded within the molecule cause its interesting magnetic properties. There is a strong exchange interaction between magnetic ions (in the order of 10^6 Oe) within the molecule.

We have applied the multipole expansion technique to the Fe_{30} molecule - one of the largest magnetic molecules. It was shown that the molecule s dipole, toroid and quadrupole magnetic moments are equal to zero (in the absence of magnetic field) so the multipole expansion starts from the octopole moment. In other words, probably the Fe_{30} molecule is the most symmetrical magnetic body synthesized so far. The magnetization process has been considered theoretically in different geometries. Some components of the octopole moment experience a jump while the magnetization rises linearly up to its saturation value. In order to have a more distinct picture of the magnetic octopole moment we have proposed an elementary magnetic octopole consisting of only four magnetic dipoles. This concept can also be useful in designing of an experiment for measurement of octopole magnetic moment components.

Low Spin-High Spin Transitions in Kondo Systems

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Considered compounds with intermediate valence and corresponding valence transitions, belonging to the family of Kondo systems, attract great attention among both physicists and chemists as they represent a useful tool for direct studying of the basic interactions which are responsible for the materials magnetic structure and for definition of the parameters of these interactions. On the other hand, materials of this kind are promising for a broad range of applications in microelectronic technology - from flat displays to novel cooling devices.

This work is dedicated to theoretical investigation of the well known a - g transition in metallic Ce and spin phase transition in cobalt valence tautomers induced by megagauss magnetic field. The calculation is based on the Anderson impurity hamiltonian. This model was shown to catch all the essential physics of the Ce and Co tautomers compounds in the vicitity of the phase transition (see, for example, D.I.Khomskii. Sov.Phys.Uspekhi 129, 3, 443-485 (1979) and M.X.LaBute, R.V.Kulkarni, R.G.Endres, D.L.Kox. arXiv:cond-mat/0110606). This work provides "microscopic" grounds for the thermodynamic approach to calculation of the B-T (B is magnetic field and T is temperature) phase diagrams of the Ce and Co compounds given by M.O.Dzero, L.P.Gorov, A.K.Zvezdin in arXiv:cond-mat/0008134 and by A.K.Zvezdin, A.S.Mischenko in arXiv:cond-mat/0209337 respectively.

The compounds in question have not yet been investigated experimentally in megagauss magnetic fields. However the experiments are scheduled to start in Sarov, Russia in near future (see the report "Field Induced Phase Transitions (FIPT) in Molecular Magnets" by A.K.Zvezdin, A.S.Michtchenko for experimental details).

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New Types of Unconventional Superconductivity in Strongly Correlated Electron Systems

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Two decades ago renaissance of superconductivity began by the discovery of superconductivity in $CeCu_2Si_2$. Since then bunch of unconventional superconducting states which cannot be described by the conventional BCS theory were identified in strongly correlated electron systems such as heavy electron systems, cuprates, ruthenate, and organic systems. In these cases, antiferromagnetic spin fluctuations are regarded as the origin of mechanism of their superconductivity in a form or another. Recently, new types of unconventional superconducting states begun to be recognized. Among them, I discuss two cases, the critical valence-fluctuation mechanism of $CeCu_2Si_2$ and $CeCu_2Ge_2$ under pressures [1-4], and a possibility of the odd-frequency gap superconductivity in the coexisting phase of antiferromagnetism and superconductivity in $CeCu_2Si_2$ and $CeRhIn_5$ [3].

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Effects of Nanoscale Phase Separation in Optical Properties of Strongly Correlated Oxides

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The concept of an intrinsic inhomogeneity of doped cuprates and manganites is among the most promising ones in the physics of strongly-correlated (SC) oxides. While the experimental evidences in support of this idea are progressively growing, its theoretical elaboration yet lags behind. In this contribution we present an approach toward the understanding of optical properties of doped SC oxides in a broad spectral range (~ 10-2 - 100 eV), proceeding from the assumption of their nanoscale electronic inhomogeneity. The model is proved able to provide a consistent quantitative explanation of a great body of experimental facts, including some old but still debatable problems, such as the nature of MIR bands and the so called marginal behaviour of the conductivity tail in the cuprates. We distinguish between the static and the dynamic effects of the nanoscale phase separation. The former ones are due to the scattering and the absorption of the radiation on the interfaces of the droplets of a highly polarizable quasi-metal phase, evolving under doping [1]. The effective medium theory (EMT) provide a reasonable description of these effects in terms of the surface plasmon (geometric) resonances in optical conductivity spectra, that fall in the mid-infrared range (Fig. 1a).

The dynamic effects are related to the collective oscillations of the droplets, localized in the minima of a rugged potential landscape, induced by doped impurities [2]. These manifest themselves in far-infrared region and give rise to the resonant features of optical conductivity (Fig. 1b), described by the generalized Drude formula within the memory functions formalism. We have shown, that the resulting spectrum shares much similarity with that of pinned charge density waves [3].

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Giant Optical Anisotropy in Doped Manganite Films as a Probe of the Nanoscale Phase Separation

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The IR optical absorption (0.1 eV < E < 1.5 eV) in the single crystal $La_{0.7}Ca_{0.3}MnO_3$ films grown on $LaAlO_3$ substrate were found to exhibit the drastic temperature evolution of the spectral weight (Fig. 1A), evidencing the insulator to metal transition, and unconventionally strong nearly T-independent linear dichroism with anomalous spectral oscillations (Fig.1 B).

Starting from the concept of phase separation, we develop the effective medium model to account for these effects [1]. The optical anisotropy of the films is attributed to the texturization of the ellipsoidal inclusions of the quasimetal phase caused by a mismatch of the film and substrate and the twin texture of the latter. Of especial importance is the possible technical application of the large dichroism of the manganite films, e.g. in the infrared polaroids.

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The Investigation of Structure of Thin SnO_x Films in Isochronous High-Temperature Annealing

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In recent years the tin dioxide thin films are widely used as transparent electrode in such devices as solar cells and displays. Also SnO_x has been developed extensively as material for toxic and combustible gases sensors. It is possible to obtain films with required parameters only knowing the mechanisms of formation of their properties. In the present work an effect of high-temperature annealing were investigated by X-ray diffraction on the structure thin SnO_x films. The tin dioxide films with thickness about 200-250 nm were deposited on polished and previously prepared Al_2O_3 substrates (polycor). Tin sputtering was executed with using a magnetron addition to VUP-5M unit in Ar and O_2 containing atmosphere. High purity (99.99%) tin targets were used. The magnetron sputtering mode parameters were as follows: the cathode voltage U_c = 175 V, the ion beams current I_{ion} = 100 mA and the argon-oxygen mixture pressure inside the chamber was 1-2 Pa. The oxygen concentration was approximately 10%. The temperature of the substrate was 200 °C. At such operating condition the films growth rate did not exceed 0.5 Å/s. The obtained films were annealed in air within the temperature range of (700-1200) °C for 1 h by 100 °C steps. After every annealing, the structure of the deposited films were investigated by X-ray diffraction using a narrow collimated (0.05x1.5) mm^2 monochromatic (CuKα) X-ray beam directed at an angle of 50 to the sample surface. The intensity of X-ray diffraction along the diffraction patterns was measured using an MD-100 microdensitometer. The average size of crystallites was estimated from the half width of X-ray diffraction lines according to Jones method. As we previously reported [1], an annealing at 550 °C for 1 hour leads to formation of polycrystalline SnO_2 phase with average crystallite sizes of about 40 Å. The results presented in this investigation show a continuous increase of SnO_2 crystallite sizes up to 230 Å as the annealing temperature increases from 700 °C up to 1200 °C. That was concluded from the fact of observed significant peaks narrowing and the simultaneous increase of peaks amplitude, too. The integral intensity of the peaks has not been significantly changed. It follows from that total volume of polycrystalline SnO_2 phase has not been significantly changed, too. It is possible to explain the increase of the crystallite sizes almost by an order by the aggregation of crystallites during annealing. As a result one can expect the ordering of structure of a total amount of SnO_2 crystallites during the high-temperature annealing. Really, the number of SnO_2 peaks on the diffraction pattern after annealing at 1200 °C is reaching about twenty and their sharpness is significantly improved. That indicates on high structural quality of crystallites. The use of various inclined and grazing angles (2.50, 50 and 100) of incidence of X-ray beam on the sample surface permits to make more exact calculation of average SnO_2 crystallite.

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Magnetic Circular Dichroism and Optical Absorption of the Yttrium-Iron Garnet by the Admixtures of Si^{4+} & Ca^{2+} Ions

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Role of Si^{4+} and Ca^{2+} ions at the charge compensation of stable complexes of Fe^{2+} and Fe^{4+} on yttrium-iron garnets (YIG) that are not destroyed in result of their after growing treatment by heating was studied. Spectra of magnetic circular dichroism (MCD) and optical absorption in the range of 600-1150 nm at room temperature on YIG monocrystals containing Si^{4+} and Ca^{2+} ions were measured. For investigations, samples of YIG monocrystals with Si^{4+} and Ca^{2+} ions of various concentrations were grown. Quantity of Si^{4+} and Ca^{2+} ions doped in YIG was defined by the microsonde and activation analysis.

Results of investigations of optical absorption spectra showed that at some concentrations of Ca2+, the coefficient of optical absorption in the range of 600-1150 nm is noticeable decreased in comparison with pure YIG. At that time, offset of the contour of the absorption band with the center at 960 nm to the area of the more short waves is observed. Besides, optical absorption in samples containing Ca, at wavelengths less than 750 nm, is increased in comparison with pure YIG. At small concentration of Si^{4+}, decreasing of optical absorption in the range 800-1150 nm and its few increasing at the wavelengths less than 800 nm is observed. Large concentrations of Si^{4+} lead to common growth of absorption in all ranges of the investigated spectrum. At that time, noticeable offset of the maximum of the absorption band at 960 nm is not observed.

Changes of quantity of Fe^{2+} -Fe^{4+} complexes that taken place in result of doping YIG with Si^{4+} and Ca^{2+} ions, are distinctly appeared in spectra of MCD of the investigated garnets. Doping of diamagnetic ions in YIG leads to increasing of power of the optical transition oscillators and to increasing of the constant of the spin-orbital interaction in excite state of iron ions. It is supposed that competition of these processes defines changes values of MCD on YIG with Si^{4+} and Ca^{2+} ions.

Behaviour of the Polar Kerr Effect in Magnetic Multilayers

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At present much attention is given to study of physical properties of magnetic multilayers with layers, thickness of which is several nanometers. The conventional theory of magneto-optical effects based on the dielectric-tensor-approach is not applicable to such multilayers, and new theories are developed to describe the magneto-optical response of ones. It is of interest to determine behaviour of the magneto-optical effects in multilayers for which the conventional theory is still suitable and to follow the change in behaviour of these effects with the decrease of thickness of layers up to values such that this theory is no longer applicable. In addition, it is of interest to determine the dependence of behaviour of these effects on parameters of substrate, nonmagnetic transparent layer adjoining to substrate (a substrate-adjoining layer), and protective layer. Because expressions, which describe the magneto-optical effects in magnetic multilayers, are complex and defies general analysing, the investigation was performed through numerical calculations. In the paper, it is presented results of numerical calculations of behaviour of the polar Kerr effect in multilayers comprising magnetic layers of ferromagnetic metal and nonmagnetic layers of metal or dielectric. It is discussed the influence of values of the optical constant of substrate on the polar Kerr effect. Much attention is given to role of transparent nonmagnetic substrate-adjoining layer in these systems. It is discussed the influence of relation between the refractive indices of the substrate-adjoining layer and the substrate, between the refractive indices of the substrate-adjoining layer and a protective layer, and between the thickness values of the substrate-adjoining layer and the protective layer. Results of calculations are presented in form of dependences of the polar Kerr rotation angle on the substrate-adjoining layer thickness, protective layer thickness, magnetic layer thickness, and on the refractive indices both of the protective layer and of the substrate.

4f Electron Contribution to Conductivity of R-Co Intermetallic Compounds in the Photon-Energy Range 1-5 eV

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The determination of the electronic structure of the intermetallic compounds of rare-earth (R) and 3d-transition metals is a nontrivial problem. It is resulted from the fact that in these compounds there are both itinerant (s, p, d) and completely localized (4f) electrons. In many works, the electronic structure of rare-earth metals and of mentioned compounds has been considered in the framework of the one electron approximation not involving the 4f electrons in scheme of energy bands. However certain of workers suppose that the large correlation of 4f electrons is no bar to the involvement of states of these electrons in band calculations.

As obtained earlier, the equatorial Kerr-effect spectra are sensitive to the rare-earth component of R-Co intermetallic compounds. Therefore the magneto-optical technique can be used for probing theoretical band models of these compounds.

In this paper, we present the spectra of the absorptive part both of the diagonal element σ_{xx} and of the off-diagonal element σ_{xy} of the conductivity tensor of $DyCo_5$ and $NdCo_5$ compounds keeping in mind that these quantities are related to the density of electron states derived from band calculations. Data cover the 1-5 eV range of photon energy at room temperature. The spectra are discussed treating the 4f electrons of these compounds as ordinary valence electrons for which the correlation energy is significant. Observed distinctions in the spectral behaviour of the absorptive part of σ_{xy} for $DyCo_5$ and $NdCo_5$ are explained as resulting from distinction between the densities of conductivity electron states in these compounds due to the fact that in $NdCo_5$ the unoccupied 4f states ($4f^{\downarrow}$ subband) are superimposed on the minority spin subband of the conductivity electrons. The absence of such superposition for $DyCo_5$ follows from the different magnetic coupling of Dy and Nd with Co in these compounds (contrary to Dy, Nd is ferromagnetically coupled with Co).

Millimetre-Wave Magneto-Optical Response of Isotopically-Substituted Single Crystals of the Organic Superconductor κ-$(ET)_2Cu(NCS)_2$

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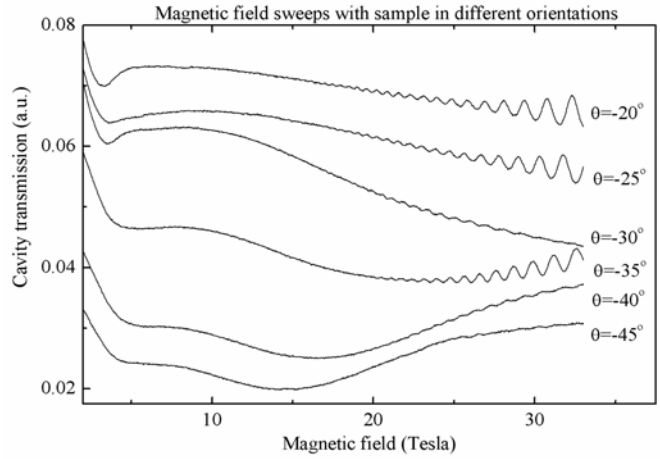
We report magnetic-field-orientation dependent studies of the high-frequency conductivity of the quasi-two-dimensional (Q2D) isotopically-substituted charge-transfer salt κ-(ET)2Cu(NCS)2 in magnetic fields of up to 33 Tesla at temperatures down to 0.4 Kelvin. The heavier isotopes 13C and 34S replace four of the six 12C and all eight 32S respectively in the ET cation. The interlayer conductivity was investigated by placing the samples in the magnetic-field antinode of a rectangular cavity resonating at about 72 GHz (TE102 mode).

The data reveal sharp resonant absorptions (for particular angles between the Q2D planes and the external magnetic field) in the vortex state of the superconductor (Josephson plasma resonances) and broad modulations of the normal-state conductivity (Fermi-surface traversal resonances). Parameters describing the Fermi surface topology are extracted and compared with those for samples with different isotopic substitutions (e.g. deuterated and protonated). Implications of these results for the nature of the superconducting state in this material are discussed.



The Border of Ferromagnetism in Ni_3Al and of Antiferromagnetism in NiS_2

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The metallic state on the border of itinerant-electron ferromagnetism in three dimensions is expected to be described by a Marginal Fermi Liquid model (see e.g. Dzyaloshinskii and Kondratenko, Sov. Phys. - JETP 42, 1036 (1976)). To look for this state we have investigated the temperature dependence of the resistivity of the simple-cubic d-metal ferromagnet Ni_3Al near the critical pressure where the Curie temperature vanishes. Ni_3Al has been selected because of its simple (Cu_3Au) crystal structure, relatively broad bands with weak spin-orbit interaction, and the availability of pure specimens.

Measurements have been carried out with a diamond anvil system designed for 4-terminal low-noise transport studies in high-homogeneity pressure media of argon or helium. The pressure was varied up to 102 kbar in situ at low temperatures and the resistivity was measured from 50 mK to 40 K.

The Curie temperature of Ni_3Al was found to collapse almost linearly with pressure and vanish at 81 ± 3 kbar. Over a wide range in temperature and pressure we observe a temperature dependence of the resistivity which deviates from that expected for a conventional metal. Our findings will be compared with the predictions of the Marginal Fermi Liquid model and also with the behaviour of the cubic d-metal antiferromagnet NiS_2 which we observed near the critical pressure around 77 kbar, where the Neel temperature vanishes.

Transport at the Border of Itinerant Antiferromagnetism in the d-electron System NiS_2

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NiS_2 crystallizes in a cubic (pyrite) lattice structure and its electronic and magnetic properties are thought to be governed by the two Ni e_g bands near half filling. At ambient pressure NiS_2 is a magnetic semiconductor and above approximately 25 kbar it has been described as an itinerant-electron antiferromagnet. Because of its cubic structure, relatively broad bands and weak spin-orbit interaction it may provide insights into the applicability of the simplest band models of magnetic quantum phase transitions.

We have measured the temperature dependence of the resistivity in stoichiometric samples of NiS_2 down to 50 mK in the metallic regime from 30 to 100 kbar. The results suggest that the magnetic order collapses at a critical pressure p_c=76±5 kbar. In the lower-pressure region of the metallic regime we observe a T^2 resistivity as expected for a weakly spin-polarized Fermi liquid.

Near p_c, however, the resistivity varies as $T^{3/2}$ over two decades in temperature down to approximately 1K. Remarkably, an anomalous form of the resistivity appears to persist to well above p_c, at least up to the maximum pressure investigated (100 kbar). We compare these findings to earlier studies in stoichiometric samples and in chemically doped samples and consider the possible origin of the $T^{3/2}$ resistivity in the light of models of transport on the border of long-range magnetic order.

Bandgap Renormalization in V-Shaped Quantum Wires

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In this paper, renormalization of bandgap energy in V-shaped quantum wires has been considered. We have constructed a possible mechanism, in the framework of random phase approximation, for calculation of screened Coulomb potential and the value of the renormalized gap energy. Two possible candidate for this form of confinement potential has been considered and mathematical framework for computation of bandgap renormalization in each case is presented. Some numerical calculation for screened potential and value of gap renormalization has been preformed and in each case these results have been described.

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Penetration Depth Measurements of Heavy-Fermion Superconductors

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We have measured the London penetration depth of $CeCoIn_5$, a quantum-critical metal where superconductivity arises from a non-Fermi-liquid normal state. In the low-temperature limit we observe a strong power-law behaviour that confirms the presence of low-lying excitations but is inconsistent with standard models of d-wave superconductivity. The careful characterisation of our sample and the use of a tunnel diode oscillator with a novel coil geometry that is inherently insensitive to non-local effects and electronic anisotropy enables us to rule out extrinsic contributions to the penetration depth signal. A systematic analysis raises the possibility that the non-Fermi-liquid renormalisation occurring in the normal state of $CeCoIn_5$ might also take place within the superconducting state.

The Stability of Orbital Ordering to the Insulator-to-Metal Transition

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Transition metal oxides show a wealth of electronic phase transitions, which are of interest for applications including data storage and transmission, and for their fundamental behavior of the charge, spin and orbital degrees of freedom. We have studied the evolution of the orbital degree of freedom using chemical substitutions and dopingin various ABO_3 type perovskite structures. Using detailed crystallographic experiments we investigate the relation between structural and electronic properties. We will report on the stability of orbital ordering and its relationship to the metal to insulator transition .

Non-Saturating Magnetoresistance in Heavily Disordered Semiconductors

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The resistance of a homogeneous semiconductor increases quadratically with magnetic field H at low fields and, except in very special cases, saturates at fields H much larger than the inverse of the carrier mobility, a number typically of order 1 Tesla. Here, we argue that a macroscopically disordered and strongly inhomogeneous semiconducotor will instead show a non-saturating magnetoresistance, with typically a quasi-linear behaviour $\Delta R = R(H)-R(0) \propto H$ up to very large fields, and possibly also extending down to very low fields, depending on the degree of inhomogeneity. We offer this as a possible explanation of the observed anomalously large magnetoresistance in doped silver chalcogenides. Furthermore, our model of an inhomogeneous semiconductor can be developed into magnetoresistive devices that possess a large, controllable, linear response.

Spin-Glass State in $La_{0.6}Sr_{0.3}Mn_{1-x}TixO_3$ (x=0.1) Perovskite

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Recently, in several investigations on manganese oxides the conclusion of a spin-glass state has made based on experimental evidences such as (i) the typical irreversibility found in field-cooled (FC) and zero-field-cooled (ZFC) magnetization, with a cusp/peak of ZFC magnetization at the spin-freezing temperature (T_g) and (ii) a frequency-dependent shift in the peak of AC-susceptibility at T_g. Nevertheless, these experimental features are also found both in super-paramagnets and spin-glasses. Thus, it is often arduous to distinguish between a spin-glass and a superparamagnet from the above experimental findings [1]. On the other hand, it is important to note that other effects such as domain wall freezing also show irreversibility of ZFC/FC magnetization [2,3]. To avoid ambiguity, besides magnetic freezing the authors [4] also pointed out that aging behaviors should be investigated in time-dependent magnetization measurements after cooling in zero-field.

We present here, the results of a thorough investigation on magnetic properties of a polycrystalline $La_{0.6}Sr_{0.3}Mn_{1-x}Ti_xO_3$ (x=0.1) perovskite by means of magnetization, AC-susceptibility, and magnetic relaxation measurements. The experimental results show the features of a spin-glass state for this sample. We associate the spin-glass behavior with which could be ascribed to the frustration of random competing exchange interactions, namely the ferromagnetic double-exchange interaction between Mn^{3+} and Mn^{4+} and the antiferromagnetic one like spins. Additionally, we propose that the magnetic disorder parameter arising from deficiency of strontium content as well as substitution of non-magnetic T^{4+} ions for Mn^{4+} ions, which introduce an enhanced antiferromagnetic (AFM) phase thus strongly competing with a ferromagnetic (FM) one, should be also a cause of spin-glass.

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Spin Dynamics in Manganites and Cobaltites

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The discovery of both colossal magneto-resistance (MR) and large magneto-caloric (MC) effects in perovskite materials with a general formula of $Ln_{1-x}RxTO_3$ (where Ln = La, Sm, Nd,..; R = Ca, Ba, Sr,..; T = Mn or Co) has renewed interests in these materials. It has been shown that there is a larger MR/MC effect in Mn-based compounds (i.e., manganite) than in Co-based ones (i.e., cobaltite). This difference could be attributed to the difference in electronic configurations and spin-dynamic properties of two typical materials. For instance, Millis et al. [1] proposed that double-exchange model alone cannot explain anomalous large magnetoresistance in the manganites of $La_{1-x}Sr_xMnO_3$ ($0.2 < x < 0.4$) and thus addition to double-exchange physics a strong spin-lattice interaction arising from the Jahn-Teller splitting of the outer Mn d level plays a crucial role. In contrast, Golovanov et al. [2] suggested that the magneto-resistance effect in the cobaltites of $La_{1-x}SrxCoO_3$ ($0.05 < x < 0.25$) could be fully interpreted in terms of the double-exchange model. To clarify the above physical situation, differences in electronic configuration and spin-dynamic property between manganese and cobalt elements in these perovskite materials must be taken into account.

In this work, besides pointing out about the difference in electronic configurations we have analyzed and discussed about differences in spin-dynamic properties between manganites and cobaltites by means of electron paramagnetic resonance (EPR). The obtained results of the EPR intensity show that all manganese and cobalt spins contribute to the EPR line in the temperature range investigated. Even though the EPR linewidth deceased with decreasing temperature for both manganite and cobaltite as usual, the shape of the EPR linewidth vs. temperature curves of these samples revealed differently from each other. It is estimated that an activation energy value for cobaltites is larger than for manganites, reflecting a strong spin-phonon coupling in manganites rather than in cobaltites in the paramagnetic temperature regime. In other words, it is the stronger coupling between spin and lattice in a manganite that evidently causes an abrupt drop in magnetization associated with ferromagnetic to paramagnetic phase transition at the Curie temperature (TC), and thus results in the larger values of CMR/MC effects in this sample.

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Dielectric Study on Li Ion Motion in Quartz and Beta-Eucryptite

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Li^+ ions from powdered beta-eucryptite were diffused into a quartz single crystal under an applied electric field. Subsequently, impedance spectroscopy in the range from 10Hz to 13MHz was used to measure the impedance and other dielectric parameters of quartz, Li-doped quartz, beta-eucryptite and beta-eucryptite-quartz couple. It was found that both beta-quartz and beta-eucryptite show single relaxation process. Li-doped quartz shows two relaxation processes revealed by the imaginary part of the impedance at high temperatures. One of the two processes present is believed to be due to the hydrogen in quartz, since it was also observed in an undoped quartz. The second one is likely due to Li ion transport, as Li ions are more mobile with increase in temperature. Also, the imaginary part of the dielectric constant of the entire sample couple (quartz + beta-eucryptite) displays only one relaxation process, which suggest that the boundary between quartz and eucryptite dominates in this case.

In alpha quartz a large number of relaxation processes were involved, hence a distribution of the relaxation processes was used to model the data. Difference in activation energies in alpha quartz can be attributed to the difference of Li ion motion through the domain walls and the bulk.

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Electronic Liquids and Mechanism of Superconductivity

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Here is proposed a concept of the physical nature of the superconductivity phenomenon taking into account a field-substance interaction. According to modern observed data the energy density of the physical vacuum exceeds significantly the energy density of any normal kind of cosmic matter, as well as that of atomic nuclear field [1]. That means any processes occurring in the substance cannot be considered without taking into account the field-substance interaction.

The field-substance interaction is accounted by using new physical invariant beating oscillations of particles [2]. The Plank's law of thermal radiation has been modified. High-frequency limit of the thermal radiation of bodies gives the information on internal spatial dimension of a wave packet of interaction between the socialized electrons with the environment, and at low temperature it is equal to ~1 μm.

The principle condition for appearing superconductivity of a material is forming electronic liquid, and obtaining luminescent properties. When in the electronic liquid the properties of continuity and wholeness are realized, a regular lattice of vortices structures (RLVS) is formed, and the material gains the property of the superconductivity. Violation of RLVS may lead to rupturing electron-phonon interaction and forming Brownian electrons. Their concentration is of ~ 10^{-4}. Absorption of the energy of violating wave by Brownian electrons leads to appearing resistance of the conductor to the electric current.

As a result of feedback with the environment wave packet of electronic gains a coherent envelope. The energy of the envelope of electron's wave packet determines a width of the superconductive slot. As a result of interaction of the overlapped wave packets of electrons there is formed a coherent envelope of the electronic liquid as a whole. That is why, when the superconductive material is placed in the magnetic field, we can observe the Messner's effect. When the energy of the magnetic field is comparable to that of the coherent envelope of the electronic liquid there appears a spontaneous fracture of the coherent energy envelope of the electronic liquid and penetration of the magnetic deep into superconductive material. This process is accompanied by appearing Brownian electrons, and, consequently, leads to appearing resistance of the material to the electric current.

All experimental results, obtained in investigations of superconductive materials, can be explained in terms of the proposed concept.

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Self-Coordinated Field of Electrons and Mechanism of Luminescence

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In investigation of structural-dynamic processes in condensed media the luminescence method is one of the most widely used spectroscopic method. However, the absence of any clear mechanism of the phenomenon makes explanation of the obtained experimental results rather difficult. We proposed a new concept on the mechanism of luminescence. In work [1] we developed basic ideas on the luminescence phenomenon. According to [1] as a result of phase correlation, self-organization, and self-compression a self-coordinated field of particles is formed in atomic-molecular systems. In spectroscopic investigations the self-coordinated field of disordered molecular systems (liquids and amorphous media) in manifested as low-frequency continuum with maximum $\nu_{max} \sim 10$ cm^{-1} -100 cm^{-1}, and half-width $\delta\nu_{1\backslash 2} \sim \nu_{max}$. As a result of self-compression in atomic-molecular systems there occurs a process of formation of socialized electrons. Phase correlation between the socialized electrons leads to formation of the self-coordinated field of the socialized electrons. The self-coordinated field of the socialized electrons is manifested as a broadband background in a spectrum of Raman scattering (RS) [2]. Energy distribution the broadband background is RS spectrum reflects the distribution of the energy of induced spins on a single socialized electron. The induced spins on the single socialized electron can be presented as a wave-packet of particle [2] after achievement of a certain magnitude of the self-coordinated field of electrons there occurs a formation of a coherent cover of the electron's wave-packet that provides their stability in time. In this case one can say about the formation of on electronic liquid. That leads to appearing a phononless maximum in the phonon wing of the electronic spectrum [3]. In transition of the socialized electrons from basic to excited level there occurs a strengthening of the coherent cover of the electron's wave-packet due to the obtained energy. In transition of the socialized electron from the excited to the basic level energy state, depending on properties of the coherent cover of the electron's wave-packet, there occurs a radiation of the obtained energy with some delay in time. Usually, this phenomenon is called luminescence. Properties of the self-coordinated field of electrons is directly related to properties of the self-coordinated field of atomic-molecules matrix. That is why any change of the properties of matrix leads to change in properties of the self-coordinated field of electrons, and opposingly. On the base of the proposed concept it was shown a possibility of solution of various problems appearing in investigation of structural-dynamic processes by luminescence method.

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Unusual Metals Near Ferromagnetic Quantum Critical Points

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Metals near quantum critical points display a variety of novel properties including non-Fermi liquid scalings in transport and thermodynamic properties, and unusual ground states, including, for example, unconventional superconductivity. These materials also pose challenges to theory. In particular, energetically low lying fluctuations associated with the quantum critical point are not included in standard first principles calculations based on density functional theory. Thus the comparison between experiment and theory is particularly important for these materials in order to characterize the nature of the spin fluctuations and their role in determining materials properties. Here, these materials are reviewed and specific examples, including layered cobalt oxides and ruthenates are discussed in detail from the point of view of their electronic structures. Finally, some new materials that may display properties related to strong quantum critical fluctuations are pointed out.

Electron Correlation at Nanoscale

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In my talk I present the fundamental properties of correlated nanoscopic systems obtained within proposed by us EDABI method combining an exact diagonalization in the Fock space with an *ab initio* readjustment of the single-particle wave functions in the resultant ground state. Explicitly, I shall address the following topics:[*]

1. the renormalized wave equation for a single particle in a milieu of other particles
2. an evolution of the electron subsystem with the increasing interatomic distance from a nanometal to a nanoinsulator of the Mott-Hubbard type
3. an appearance of the Mott-Hubbard gap in molecular and cluster systems (such as H_4, H_6)
4. hydrogen molecule ladders: their absolute stability and magnetic properties.
5. Also, a transition from molecular (band) insulator to the Mott insulator.

Our method provides the evolution of the correlated system as a function of lattice constant. In this manner, it complements the usual analysis of the system properties, which is performed as a function of model parameters. Here these parameters are determined as well.

[*]In cooperation with E. Gorlich, J. Kurzyk, R. Podsiadly, A. Rycerz, W. Wojcik, and R. Zahorbenski.

Non-Fermi Liquid Form of the Low Temperature Resistivity in the Ferromagnets YNi_3 and Ni_3Al

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We present high resolution measurements at ambient pressure on high purity crystals of YNi_3 and Ni_3Al in the temperature range from 50 mK to 7 K. Although both systems are well in their low moment ferromagnetic state there is no clear evidence for a T^2 temperature dependence of the resisitvity as would be expected from Fermi liquid theory. Instead we observe and anomalous temperature exponent of 1.5-1.6 all the way down into the millikelvin regime. Because of the comparitively simple structure in particular of Ni_3Al and a nearly continuous magnetic ordering transition in both YNi_3 and Ni_3Al, the present measurements together with studies in an applied magnetic field will allow a quantitative comparison with the predictions of spin fluctuation theory.

The Special Coatings for Intensification of Radiation Heat Transfer

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Usually, radiation heat transfer is considered in an assumption of a convective heat transfer absence. It is considered that a heat transmission inside of a solid-state is occurred by heat conductivity. In these conditions the process of the heat transfer is determined by the following factors: emission, absorbtion and reflection of radiant energy on the solid-state surface. Summarized effect of the heat transfer depends upon the ratio between an energy absorbed with the given solid-state and between an energy emitted by the solid-state. The emitted energy accordingly to the Stephan-Bolsman law depends upon a temperature of the solid-state and an emissivity at the preset temperature. It follows that the radiation heat transfer may be intensified by means of coatings having a high emissivity value, mechanical and adhesion hardness, and saving all these properties at the sharp temperature overfalls.

In the given work the preliminary results of experimental investigations of the coatings with high value of emissivity, influences on intensity of radiation heat transfer are given. Experiments were carried out on the cylindrical form samples from aluminium alloy D-01 with the following dimensions: diameter – 60 mm, height – 15 mm. Coatings were deposited by chemical etching. It is showed, that increasing of heat transfer intensity on 8 ÷ 10 % is caused by increasing the emissivity of the sample's surface by means of special coatings, and the thermo cycling in this case has no influence on the emissivity properties of coating.

Anomalous Thermal Conductivity of the Spin-Peierls Compound $CuGeO_3$ in Magnetic Fields: Proximity to Integrable Models and Possible Heat Conduction by the Soliton Lattice

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We report anomalously large thermal conductivity κ of $CuGeO_3$ in both paramagnetic and high magnetic-field phases. Divergence of heat conductivity is mathematically derived in integrable systems due to conservation of energy flow. Therefore, recent observations of large spin thermal conductivity in low dimensional spin systems are attracting much interest, associated with the integrability of the 1D spin-half Heisenberg model. In the spin-Peierls compound $CuGeO_3$, we reported that the S=1/2 Cu-O-Cu chain carries hundreds of times more heat in zero magnetic field than normal 3D paramagnets does. More interestingly, κ significantly increases with the application of magnetic fields above 14 T. In such a high field, the system turns into the magnetic incommensurate phase and "spin-soliton lattice" is formed. Noting that such a soliton system as described by the sine-Gordon model provides another example for integrable models, possible proximity to the integrability is discussed as a reason for the anomalous κ(H).

Thermodynamic Study on the Ferromagnetic Superconductor UGe_2

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The heat capacity and magnetization measurements under high pressure have been carried out in a ferromagnetic superconductor UGe_2. Both measurements were done using a same pressure cell in order to obtain both data for one pressure. An anomaly is found in the heat capacity at the characteristic temperature T^* where the magnetization shows an anomalous enhancement. The thermodynamic consideration suggests that a second order phase transition takes place at T^* at least under high pressure close to P_c^* where T^* becomes zero. The heat capacity anomaly associated with the superconducting transition is also investigated, where a clear peak of C/T is observed in a narrow pressure region ($\Delta P \approx 0.1$ GPa) around P_c^* contrary to the previous results of the resistivity measurement. These results support that the mass enhancement of quasiparticles just below P_c^* is due to the low energy magnetic fluctuation which causes the superconductivity.

On the Thermomagnetic Instabilities in Composite Superconductors

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Magnetic flux penetrates into superconductors in the form of quantized flux lines. These flux lines can be pinned by tiny material inhomogeneities (or pinning centers), which prevents their motion. When flux lines are moving, a heat is dissipated, and the resulting temperature rise weakens the pinning. This can lead to a thermomagnetic instability of superconducting state, which accompanied by abundant heating and macroscopic redistribution of magnetic flux. In this work the thermomagnetic instability of the superconducting state of composite superconductors is analyzed taking into account the dissipation effects. Analytical results for a thermomagnetic instability in the viscous flux flow regime of superconductor by using a model based on the heat conduction equation coupled with Maxwell's equations are presented. The critical magnetic field $\mathbf{H_C}$ and critical thickness $\mathbf{l_C}$ for a bulk composite superconductor sample has been found analytically using the dynamic approach. It is shown that the critical magnetic field depends on the effective values of thermal conductivity, specific heat, and heat generated by electromagnetic phenomena. A numerical values for $\mathbf{H_C}$ and $\mathbf{l_C}$ are in a good agreement with experimental dates. The result obtained enables us to propose a possible version of transition from superconductor state to normal state.

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Interplay of Coulomb Blockade and Quantum-Mechanical Tunneling in the Low-Conductivity Phase of Granular Metals

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We study the effects of the interplay of Coulomb interaction and inter-grain quantum-mechanical tunneling on the conductivity of a normal granular metal. We consider temperatures well below the charging energy E_c of individual grains yet large compared to level spacing in the grains, and disregard weak localization effects. When the inter-grain tunnelling conductance $g>>1$, the conductivity σ decreases logarithmically with temperature ($\sigma/\sigma_0 \sim 1- (1/2\pi gz) \ln(g\beta E_c)$) , while for $g \rightarrow 0$, charging effects are important, and the conductivity shows activated behavior ($\sigma/\sigma_0 \sim \exp(-\beta E_c)$) . For intermediate values of g we find that competition between charging and tunneling effects leads to $\sigma \sim (1/z)\exp(-2\sqrt{\beta E_c \ln(2\pi/gz)})$, where z is the effective coordination number of a grain.

Change of Electron Configuration and Local Structure Effects on Curie Temperature of Mn-Site Substituted Lanthanum Manganites

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Magnetic properties and local structure of $La_{0.7}Ca_{0.3}Mn_{1-x}Sc_xO_3$ lanthanum manganites were studied by ac susceptibility measurements and extended X-ray absorption fine structure (EXAFS) analysis. The substitution of Sc^{3+} ion for Mn^{3+} one damages a way for the motion of itinerant e_g electron causing a weakening of double-exchange interaction and decreasing of Curie temperature, T_c. EXAFS study did not show any significant change of local parameters of MnO_6 octahedral. It is argued that the observed strong decrease of T_c with x is mostly caused by the difference in electron configuration between the Mn^{3+} and Sc^{3+} ions and, partially, by the change of local parameters of MnO_6 octahedra because the larger Sc^{3+} ion than the Mn^{3+} one. It is supposed the method to distinguish the effect of above two factors on Curie temperature.

Magnetic Susceptibility and Optical Absorption Spectra of $DyAlO_3$ Orthoaluminate

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The present paper reports results of an experimental polarization study of an optical absorption spectra of $DyAlO_3$ because the anisotropic nature of Stark components of an absorption line can give additional data on the energy spectrum and the symmetry of wave functions of the Dy^{3+} ion in the orthoaluminate structure. Note that in comparing the data of optical measurements with the results of studying the magnetic susceptibility χ measured along the c-axis of the rhombic $DyAlO_3$ crystal shows much potential for the given approach to the analysis of optical data. This susceptibility is associated with the fact that the wave functions of excited states are admixed to the function of the ground state on applying an external magnetic field H. Because of this, χ is extremely sensitive to the choice of wave functions of excited states of the ground multiplet $^6H_{15/2}$ of the Dy^{3+} ion in $DyAlO_3$.

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Magnetooptical Research of Stark Splitting of Excited States of Tb^{3+} Ion in $Y_3Al_5O_{12}$

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For most rare-earth (RE) ions of paramagnetic garnets, the odd component of the crystalline field (CF) responsible for mixing the excited $4f^{n-1}5d$ (or 5g) configurations with the ground $4f^n$ and removing the prohibition in parity for the 4f-4f transitions has been unknown practically [1]. Some of the parameters of the odd CF in garnets were calculated for the RE ions of Nd^{3+} with the model of exchanging charges [2] and defined for the Dy^{3+} [3] and Yb^{3+} [4] by comparing the theoretically calculated distribution of optical spectrum intensities with the experimental data. For the RE Tb^{3+} ions in garnets (not only in them), in spite of great importance of using these parameters to describe the optical features of the 4f-4f transitions, such a problem was not solved. Therefore, in this work for the first time an attempt has been made to direct define possible quantitative relations between the parameters of the odd CF-coefficients B_{tp} and the Judd parameters of the 4f-4f transition intensity - $\Xi(t,l)$ [1] for the RE Tb^{3+} ions in the garnet $Y_3Al_5O_{12}$ (YAG) by comparing the theoretically calculated spectra of magnetic circular polarization of luminescence (MCPL) with experimental data. A certain advantage of this approach for fitting calculations is additional selection rules essentially restricting the number of possible 4f-4f transitions that are considered for modeling of the optical spectra of RE compounds in the magnetic field H. In this connection, we carried out a detailed study of the spectral dependence of MCPL degree $P= (I_+ - I_-)/(I_+ + I_-)$ (where I_+, I_- are the intensities of the orthogonal circular components of luminescence) and of luminescence in the "blue" band region (20280-20450 cm^{-1}, connecting with the 4f-4f radiative transition $^5D_4 \rightarrow {}^7F_6$ of the Tb^{3+} ion in the YAG garnet structure $C_{Tb} \approx 5$ wt. %). The comparison of the spectra of MCPL degree and fluorescence demonstrates that an observed spectrum of magnetopolarization luminescence is formed by superposition of the linear dependencies P (vanishing at the luminescence band center), connected by the diamagnetic"contributions in MCPL (so-called A-terms [5]). By using the well-known symmetry selection rules for the matrix elements of the electrodipole transition [5] and the values of energy of the Stark sub-levels of the $^5D_4$ and $^7F_6$ multiplets, calculated in this work by the numerical methods (see also [6]), we constructed a diagram of the radiative 4f-4f transitions responsible for appearing of the special features of the MCPL degree spectra for YAG:Tb^{3+} within the given range of energy. Moreover, from experimental data, obtained by us, we have found the relations between the parameters of the odd CF in YAG:Tb^{3+} : B_{32} $\Xi(3,4)$ / $B_{52}\Xi(5,6)$ and B_{54}/B_{52}. It is interesting to note that the relations found by us between the parameters of the odd CF allow us to explain the distribution of intensities for some luminescence lines of the 4f-4f radiative transition $^5D_4 \rightarrow {}^7F_6$ at T=78 K. Moreover, the above-obtained results evidence a certain correlation in the behavior of the coefficients B_{52} and B_{54} of the odd component of the CF for the RE ions of Tb^{3+}, Nd^{3+} [2] and Dy^{3+} [3] in the structure of the YAG garnet.

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The Search for and Study of New Low Dimensional Magnetic Compounds

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The physical properties of low dimensional magnetic systems are distinctly different from those of conventional three-dimensional magnets. Some new results conserning search and study of new low dimensional metal oxides and galogenides are presented as follows:

1. A new spin-ladder family material $BiCu_2VO_6$ is studied by means of the magnetic susceptibility, heat capacity and neutron inelastic scattering measurements on powder sample. Single ground state and a finite spin gap are confirmed by thermal-activated type susceptibility and by distinct peak in spin excitation. Triple narrow-band structure in spin excitation spectrum, probably due to complex crystal structure, is observed and the possibility of weakly-interacting spin-cluster system is discussed.

2. The results of Cu and Cl nuclear magnetic resonance experiments and thermal expansion measurements in magnetic field in the coupled dimer spin system $TlCuCl_3$ indicate that the field-induced antiferromagnetic transition as confirmed by the splitting of NMR lines is slightly discontinuous. The abrupt change of the electric field gradient at the Cl sites, as well as the sizable change of the lattice constants, across the phase boundary signal that the magnetic order is accompanied by simultaneous lattice deformation.

3. The single crystals of mixed-valent metaloxide compound $LiCu_2O_2$ were grown by spontaneous crystallization from the melt. The temperature dependence of magnetic susceptibility shows a broad maximum at $T \sim 36$ K characteristic for a low-dimensional magnets. At $T_N = 22$ K a kink in susceptibility signals the formation of three-dimensional long range antiferromagnetic order.

The smeared peak in specific heat is observed at about T_N, but the large part of magnetic entropy is released above this temperature. The neutron scattering study had established a helix antiferromagnetic spirals propagating along the two-leg ladders formed by Cu^{2+} ions.

Magnetostructural Effects in FeS Troilite

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Troilite (FeS) has an antiferromagnetic sublattice of iron atoms. Magnetic effects are important in determining the structure of troilite, and the related pyrrhotite minerals (Fe(1-x)S) are derived from the troilite structure via the ordering of iron-vacancy defects. Troilite is rare and thus there is a dearth of experimental data. Using the HPCx high-performance computing facility, we have been able to simulate troilite to very high accuracy using the VASP plane-wave code [Kresse and Furthmuller 1996]. We obtain values for the lattice parameters within 1% of experimental values with a bulk modulus in excellent agreement with experimental results [King and Prewitt 1982, Kusaba et al. 1997] and previous simulations [Martin et al. 2001]. Accurate simulations of the troilite and pyrrhotite structures are an essential tool in elucidating the interactions governing the ordering of iron vacancies in pyrrhotite.

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Investigation of Paramagnetic Centres in Yttrium-Aluminium Garnet $Y_2Al_5O_{12}$

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Investigations of properties Yttrium- Aluminium Garnet (YAG) give a big significance with their application as magnetic and optical materials and also for studying of mechanism of possible to frustration of generation of laser radiation under the act of hard kind of radiation and revealing radioactive firmness of these materials.

It's determined, that γ-radiation forms series defects of crystalline lattice, which was defined by optical absorption and electron paramagnetic resonance (EPR). γ-rays furthers exciting luminescence of YAG, activated by TR^{3+} ions, as at the room temperature, as at 77 K. Also paramagnetic centers was studying in crystals, which radiated by γ-rays at the 77 K. This spectrum of EPR in depends on crystal orientation and has fine structure with g-factor 2.0186. Discovered twelfth multiple component signal indicates an opportunity of formation defects, which connect with two aluminium ions (spin of nucleus (S_A =5/2).

Radiation by neutrons leads to appearance additional regions of optical absorptions and luminescence to generation of paramagnetic centers with g-factor 2.0060.

Intensity of paramagnetic signals increases with increasing dose of neutron radiation. The temperature heating up to 873 K leads to decreasing intensity of signal EPR and repeated γ -radiation appeared EPR signals again, but with g-factor 2.0075. Comparison of results of optical and EPR investigations give us basis to suppose, that EPR-signal with g-spectrum 2.0075, absorption regions (380 nm) and luminescence (420 nm) are connect with the same center.

Conclusion:

1. Changing of row magnetic and optical properties yttrium-aluminium garnet was revealed by act of radiation.

2. It's found region of optical exiting luminescence YAG Nd^{3+} and thermal heating of radiation defects and common re-establishment their physical properties.

3. For the first time was found region of exciting of YAG-crystal contain to Nd^{3+}.

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Charge Transfer Transitions in 3d Metal-Based Oxide Compounds

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We have studied the charge-transfer (CT) transitions O,2*p* ➔ *Me*,3*d* in octahedral MeO_6 complexes, *Me* being 3*d* metal. We present a self-consistent description of the CT bands in 3*d* metal-based oxide compounds which allows to correct the current interpretation of optical spectra. Exemplifying our general analysis, we have modeled the CT band in the optical spectrum of $LaVO_3$. The band consists of 81 lines ranging from 1.9 to 14.4 eV. This shows the groundlessness of the wide-spread opinion that the CT transitions spectrum has a simple (1-2 lines) structure.

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Field Induced Phase Transitions (FIPT) in Molecular Magnets

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The magnetic cumulation technique and magnetic explosion generators have been studied since about 1950 independently in Russia and in the USA. The Russian project was headed by A.D.Sakharov and the American by F.Villing and E.Teller. Now the magnetic cumulation setup (MC-1) settled in Sarov, Russia allows to obtain magnetic fields up to 10^3 Tesla in a few cm^3 cavity in a broad temperature range with high stability.

The generated ultrahigh magnetic fields with the values comparable to that of intra-molecular fields are valuable means for many sided research in solid state physics. In this report we present a brief descriprion of the explosion method and some results of its application. The magnetic coil compensation method has been used to study the first order phase transitions in a broad range of fields and temperatures. The Faraday method has been applied to measure the second order magnetic phase transitions. A number of modern materials were studied experimentally and theoretically: first order phase transitions in RCo_2 compounds, second order transitions in $KMnF_3$, MnF_2 and steplike magnetization process (transition from ferrimagnetic to ferromagnetic phase) in some molecular magnets - $Mn_{12}Ac$, Mn_6Rad_6 and V_{15}.

These magnetic measurements provide us with a direct and unique method of determination of the exchange interactions between magnetic ions within a nanocluster. On the other hand, the knowledge of the magnetic interacion energies is important for molecular engineering in order to design new magnetic nanoscale materials with desireable properties.